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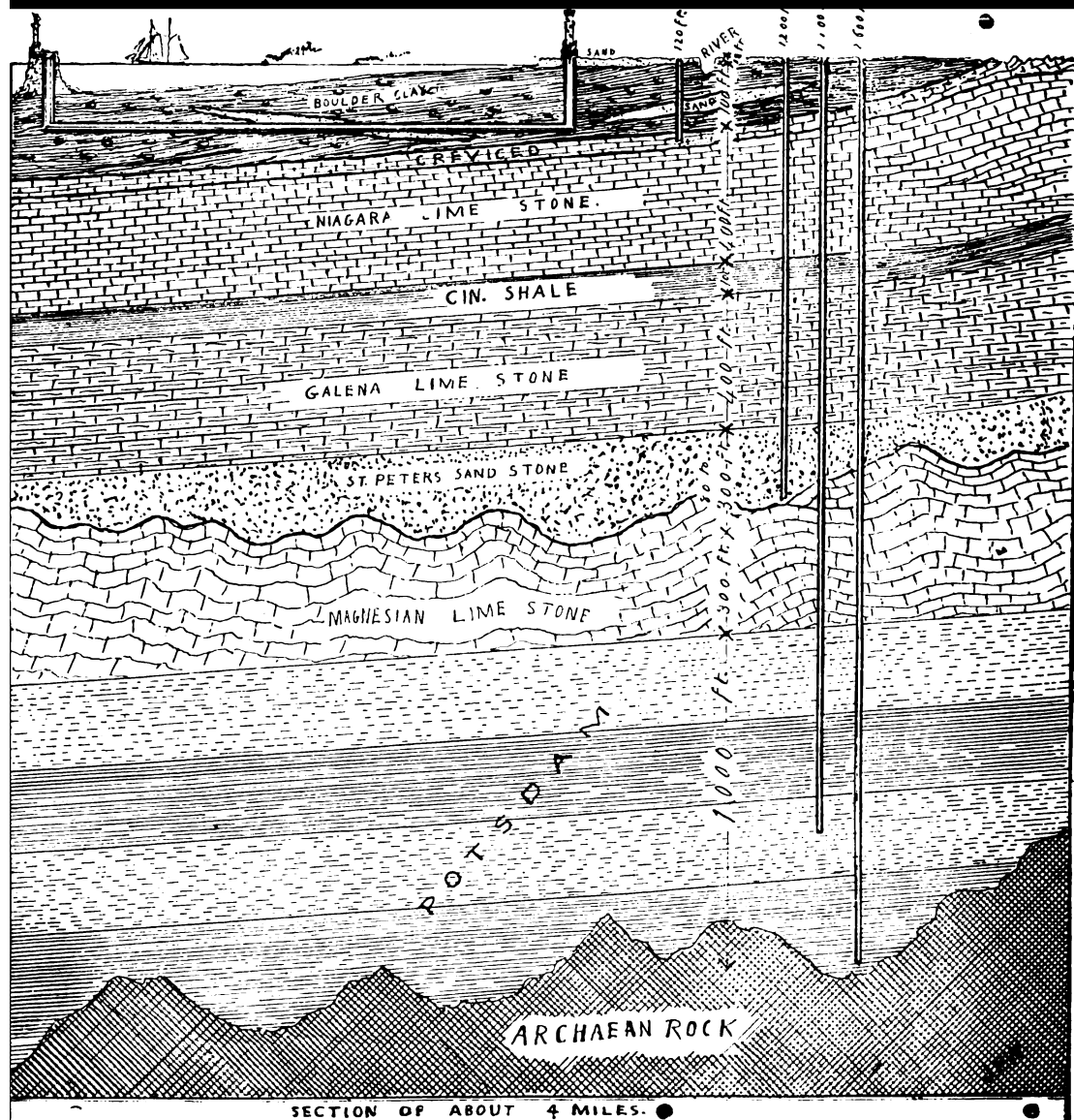
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Chicago Academy of Sciences

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Vol. I.

No. I.

BULLETIN

OF THE

CHICAGO ACADEMY OF SCIENCES.

GLACIAL MARKINGS OF UNUSUAL FORMS

IN THE

LAURENTIAN HILLS.

By EDMUND ANDREWS, M. D., LL.D.

CHICAGO:

C. H. BLAKELY & CO., PRINTERS, 88 DEARBORN STREET

1883.

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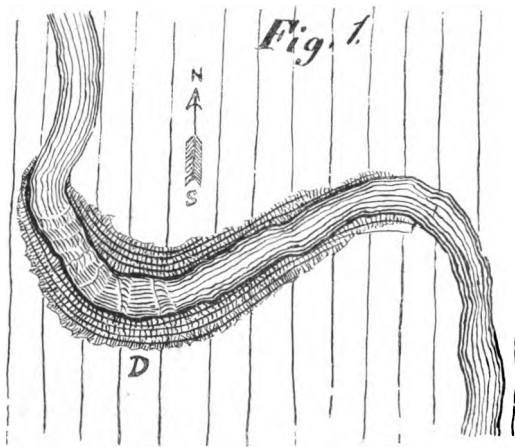
BY EDMUND ANDREWS, M. D., LL.D.

Two summer vacations spent in camps and canoes where the Laurentian Hills skirt the northeast shore of Lake Huron, have brought to my notice some glacial phenomena of very unusual forms.

These hills are for the most part ranges of hard metamorphic rock, which at the boulder drift period were scraped bare and washed clean of all earthy covering, so that the present forests grow mostly in a thin stratum of vegetable mold of later origin. The irregular and knobby eminences, as the country slopes gradually beneath the level of Lake Huron, project their countless summits above the water in a wide belt of wooded islands, which extend along the coast some two hundred and fifty miles. The British chart (Bayfield's original) marked fifty-two thousand of these islands. The rocks along the coast are mostly white quartzite and gneiss, and are everywhere covered with glacial markings which are often of peculiar forms. North and northeast of Grand Manitoulin Island the Cloche Mountains stretch east and west about thirty miles along the coast. These mountains are of white quartzite, and the strata are nearly perpendicular, with the strike parallel to the range, that is, east and west. They are covered everywhere with striations which, owing to the intense hardness of the material, retain their forms with beautiful distinctness.

CURVED STRIÆ.

Among the interesting phenomena of the region are the thousands of curved striations. Fig. 1 is from the stream that comes down by



the Hudson's Bay Post, about fifteen rods above the cascade. There is a broad gap here in the Cloche range, through which some fine lakes lying behind the mountains send their surplus waters to Lake Huron. The stream apparently ran in the same bed before the drift period, for the little gorge at D, (indicated in the figure

by shading,) scarcely ten feet deep, is well scored to the very bottom with glacial striæ following all the sinuosities of the stream. The general course of the striæ of the gap is southward. The perpendicular lines in the figure indicate this general direction, while the curved lines in the shading of the gorge (D) show how the striæ bend abruptly in order to follow around the hard quartzite banks of the stream, and, in doing so, even run a little contrary to the main course of the glaciation.

The crest of the Cloche Mountains is crossed by a multitude of giant grooves, some of which reach a depth of six feet and are twenty feet across. These markings run southward, rounding slightly over the summit of the range and down its slopes, until they reach the crests of its southern precipices, where they terminate abruptly, as it were sailing away into the air and not forming any grooves down its face.

Sixty miles southeast of the Cloche gap, and off the mouth of French River, there lies outside of the general insular belt a beautiful cluster of wooded islets, the Bustard Isles. The group consists of about two hundred *roches moutonnées*, upon which sufficient vegetable mold has accumulated to support a growth of trees. Wherever this soil has been washed away by the waves, the striæ come to view.

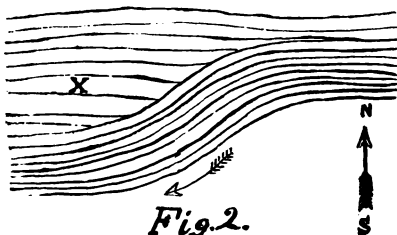
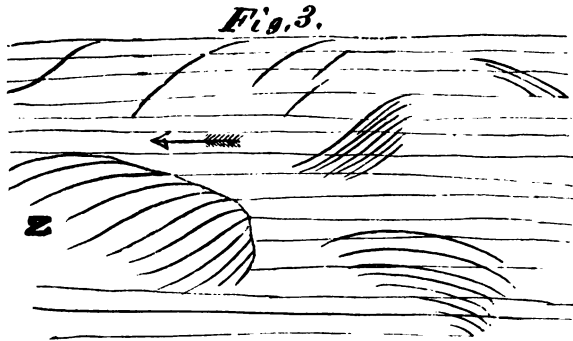


Fig 2 was sketched from a sample of curved markings near one of my camps on the north side of the group. The sketch represents about fifteen feet of the length of the marks. It is not easy to see any reason for the curve, as there was no prominence of rock in the direction of *x* to turn the ice. In fact the islet was highest on the side toward which the ice turned at the first curve. The compass-mark is approximately, but not precisely correct.

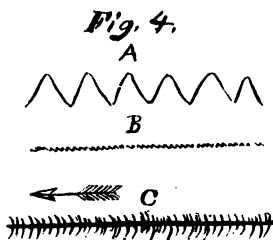
Fig. 3 is copied from my notes of observation on striæ found at Negaunee, in northern Michigan. A knob of rock uncovered by iron-miners was of such material that it



showed on its irregular surface the finest markings, even to hair-lines.

There were upon this rock some curves, which were evidently deflections caused by knobs and bosses on its surface, as for instance at *z*, while other markings were erratic, and curved without obvious cause, as though the ice had been swayed by swirling currents as the waters moved about it. The most of the glaciation was in the direction shown by the horizontal lines. The curved lines in the figure were selected from hundreds of others on a surface of about two rods square. They were generally short, and some of the curves were of less than one foot radius.

SERRATED STRIÆ.



Behind the Cloche Mountains the Spanish River runs westward into Lake Huron. A branch of this stream, called the Sable, coming down from the hills on the north, presents near its mouth five cataracts within a distance of eight miles. At the lowest of the falls the river runs through a sort of rock flume, having upon both sides walls about forty feet in height, not quite vertical but with a slight inclination away from the stream. These cliffs are smooth and striated in every part parallel to the stream. At the falls, which are only a few

feet in height, the striæ curve with the descent, and also laterally with a bend of the cliff. On the walls of the gorge are to be seen a few examples of the marks A and B, fig. 4, and the mark A is serrated, the serrations being perhaps twelve inches high.

It is not easy to explain the cause of these striæ in a perfectly satisfactory manner, but it would seem that some of the ice must have been driven through the flume with a rocking motion, so that the boulders on its lateral margins were caused to take a zigzag course, scoring the walls in a corresponding form. In B, fig. 4, is represented a section of certain marks produced in the same manner as those cuts of a stone-planing engine where the tool trembles or vibrates in the grasp of the machine so as to cut a finely serrated groove. In the specimens found the serrations were about one-quarter of a centimetre from crest to crest. It is possible that the regular vibrations there recorded on the rocks had some fixed mathematical relation to the velocity of the ice, which might be determined by calculation or experiment.

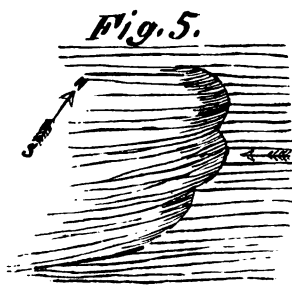
NEW INDEX OF THE DIRECTION OF MOTION.

The mark c, fig. 4, was copied from a granite *roche moutonnée*, at the fishing hamlet of Killarney, near some quartzite ranges named "Killarney Mountains." Striæ of this type show a multitude of minute cracks, extending laterally and curved so as to present their points forward in the direction of the glacial movements. Only large grooves and scratches show this peculiarity. It is a very convenient mode of determining the direction of the motion, for the pressure of the boulders which made the scratches as they moved forward, caused the transverse crevices to present their concave sides always forward. It is well known to engineers that in brittle substances the forms assumed by fracture vary with velocity of the impact, so that there is probably a time relation involved here also, which would make it possible to determine the approximate velocity of the ice which carried the boulders. Such a calculation, if based upon carefully repeated experiments, might prove an important contribution to our scanty knowledge of the Drift Period.

SCOOP-MARKS.

These are singular phenomena, and very difficult of explanation. They are of two varieties, the striated and the unstriated. Fig. 5 is a diagram intended to illustrate a typical form of the striated variety. The marks consist of shallow, elongated excavations, or troughs,

which may be many feet in width. They run nearly in the direction of the general striation of the locality, and look as though a huge



flour-scoop had been inserted into the rock and had cut out enough of its substance to make a smooth and rather shallow concave channel. The end toward the east or northeast, from whence the drift action came, is abrupt, sharply defined, and, although the angle of junction with the general surface is obtuse, yet this line of junction is a sharp and clearly-cut edge, and

not a gradual sloping or rounding into the general level. The interior of the concavity is well striated in the direction of its own length, but the scratches are never continuous with those of the general surface northeast of the head of the scoop-mark; and conversely the striæ of the general glaciated surface are all cut off abruptly at the head of the scoop, and never descend at all into it.

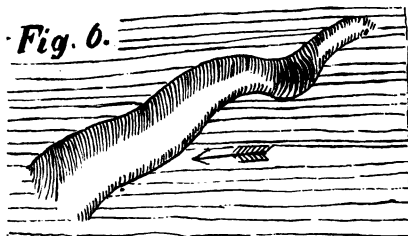
The tail of the channel grows shallower as it runs west or southwestward, and its thin extremity merges imperceptibly into the glaciated surrounding surface.

A few of the scoop-marks are nearly flat in contour, and are only recognizable where they cut abruptly through at an obtuse angle into the general face of the rocks. The interpretation of these anomalous scoop-marks is somewhat perplexing. At least, after considerable study of them, I am quite unable to frame a plausible theory of their origin other than the general one, that ice was the agent.

The unstriated scoop-marks differ considerably from the others in form, and on the average are smaller, seldom exceeding two feet in breadth. There are no glacial markings in their smooth but unpolished concavities.

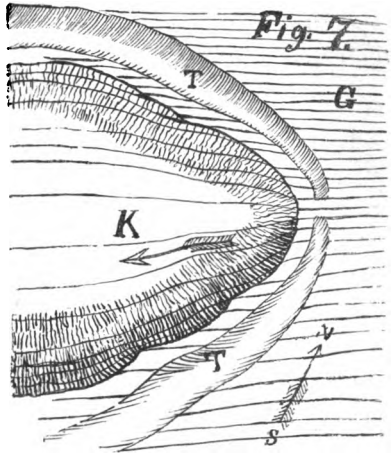
Whether they never contained any striations, or whether the markings have been erased by sand and water driven through them before the Drift Period closed, is not easily determined.

These channels generally are crooked, without obvious reason (see Fig. 6), and are narrowest at the end toward the northeast, from which direction the drift came. Toward the opposite extremity they grow wider and more shallow,



disappearing finally and vaguely into the general ice-marked surface of the locality. The specimen shown in fig. 6 is, perhaps, six feet long, sunk in granite, without any crevice, vein or visible irregularity in the rock face to account for its excavation at that spot. These channels often differ pretty widely in direction from the adjacent striation, and the end nearest the northeast commences as a rounded depression, without the clear-cut edge presented by the striated scoop-marks. The darkly shaded spot in fig. 6 was deeper than the rest, as if from a species of "pothole" action.

Most of the striated scoop-marks are not independent phenomena, like fig. 6, but evidently are appendages to adjacent knobs and projections of rock. The type of such cases is represented in fig. 7, which is a diagram of the plan of numerous specimens seen along the eastern shore from Killarney to Parry Sound, a distance of about one hundred miles. K is a boss or knob of rock projecting above the general glaciated surface in an oval form, in fact a *roche moutonnée*. The specimen in fig. 7 is about four feet high, fifteen feet wide and thirty long, but the sizes of others vary without any obvious rule. The observed specimens are mostly in gneiss. The horizontal lines in the diagram show the general direction of the striation in the locality — nearly west-southwest as shown by the arrow. It will be seen that as the striæ approach and rise upon the surface of the knob they are deflected to the right and left, and sweep over it in an oblique course. This sort of curved deflection, partly over and partly around obstacles, is common to the whole coast, so that in many places almost all the striæ are curved by the influence of the knobby surfaces of the gneiss and quartzite.



T T are two unstriated scoop-marks, having a length of about ten feet and a width of twelve inches. They begin vaguely near to each other, but not in contact, close to the northeast end of the knob, and rapidly deepen to six inches or more as they curve about its two sides, after which they grow wider and more shallow until they become lost in the general glaciation along the sides of the rocky buttress. There are no striæ in these concavities, and their inner

borders do not touch the base of the knob, but keep a foot or more away from it, leaving a narrow strip of level striated rock between the margins of the troughs and the eminence.

In a multitude of cases, just as in this one, it is sufficiently clear that the resistance offered by knobs of rock to the progress of the drift agencies in some way determined the presence and direction of these scoop-marks.

The great belt of fifty-two thousand islands, above referred to, varies from three to fifteen miles in width, and is about two hundred and fifty miles long. Beginning at the Ste. Marie river, it first outlines the north channel by the great Manitoulin group, and thence passing southeast through Frazer Bay, continues along the whole east coast of Georgian Bay and terminates near Collingwood.

Near the mainland, the islands are mostly metamorphic, with a very distorted stratification, but a few of those on the lakeward border of the belt are of Silurian limestone, with the strata dipping gently away from the nearest metamorphic hills.

This almost untrodden solitude, which has lain forgotten by the crowds of summer pleasure-seekers, is well worthy of a visit by the lover of nature. The magnificent panoramas of the island belt, as viewed from the summit of the LaCloche and Killarney ranges, are unique, and in themselves well worth the journey to the region. Fortunately, they are as yet almost unknown to sight-seers, and still remain in their original freshness and silence.

NO. 6 EAST SIXTEENTH STREET,
CHICAGO, ILL.

VOL. I.

No. II.

BULLETIN
OF THE
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OBSERVATIONS ON FLUVIATILE DEPOSITS
IN
PEORIA LAKE, ILLINOIS.

BY REV. JOSEPH D. WILSON.

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BY REV. JOSEPH D. WILSON.

All running water wears away the land over which it flows; that is, it removes particles of soil, sand, etc., to lower levels. It does this in three ways:

FIRST. By taking into itself soluble matter and depositing it by evaporation.

SECOND. By holding in suspension particles of small specific gravity while itself in a state of agitation, and laying them down when it comes to a state of rest.

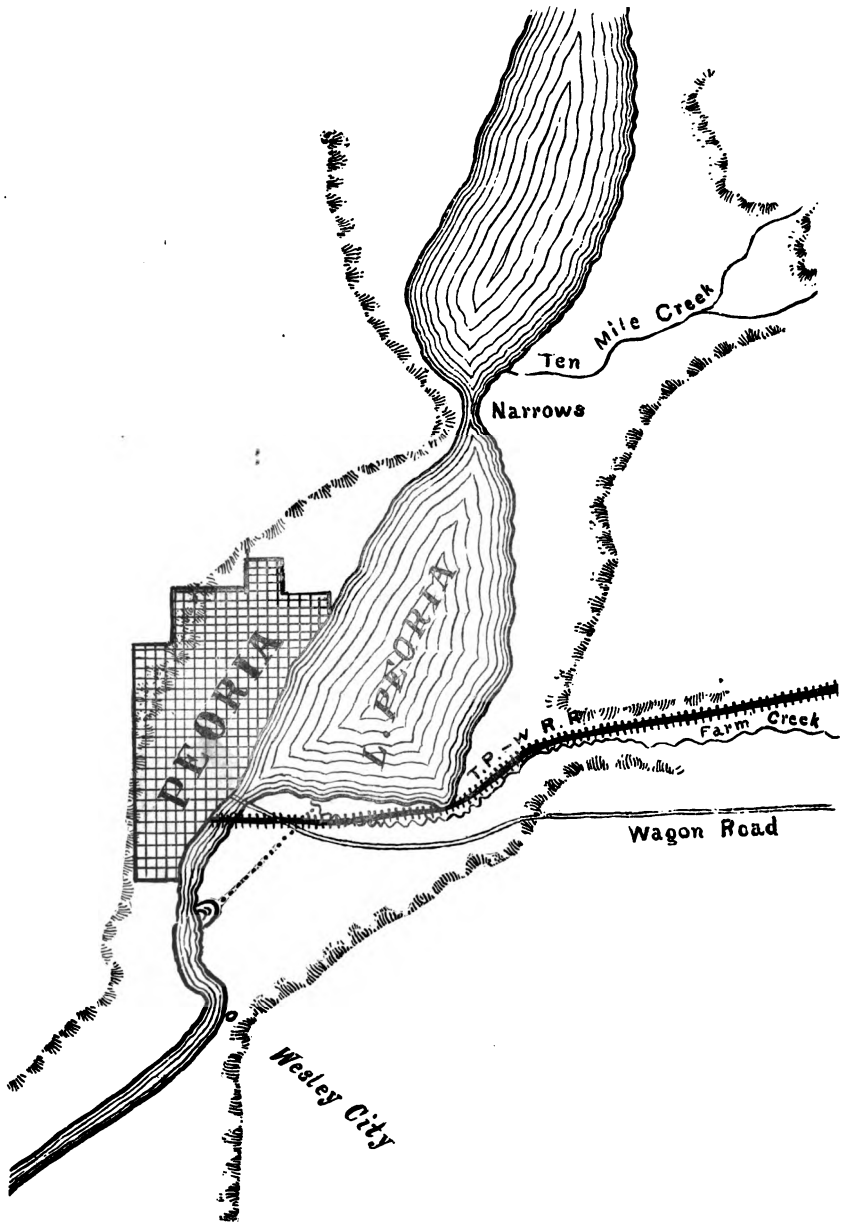
THIRD. By rolling or pushing heavier substances, sand and gravel, along the bottom, until bars or counter-currents prevent a further flow.

While erosion is going on in the upper levels, land is formed in the lower. The denudation being widely extended, is not ordinarily noticeable, and the land formation frequently goes on unobserved for considerable time, being under water, and not until navigation is interfered with, or the made land emerges above water, do we suspect the amount of work which is done by even a small stream.

The stream works all the time, day and night, and whether its waters be clear or muddy it is always doing something to level the hills and fill the ocean bed.

The following pages are a record of the work done by a little stream which falls into Lake Peoria, opposite the city of Peoria. Close observations were made during the years 1876, '77, '78, and occasional records and observations from 1867 to 1876 were obtainable.

Lake Peoria is an expansion of the Illinois River. What is known by the name of Lake Peoria is about fifteen miles long, and in ordinary stages of water about two miles wide. The lake is divided into two portions, the lower portion being four miles long



and separated from the upper lake by the "Narrows," a strait 500 feet wide. This paper deals with the lower lake. Except in high water there is no perceptible current in the lake, but the rapid flow in the constricted and shallow "narrows" and at the outlet shows that a current does exist. Being comparatively quiet, however, facilities are afforded for the deposit of the burden of mud and sand which Farm Creek has until recently been carrying into it.

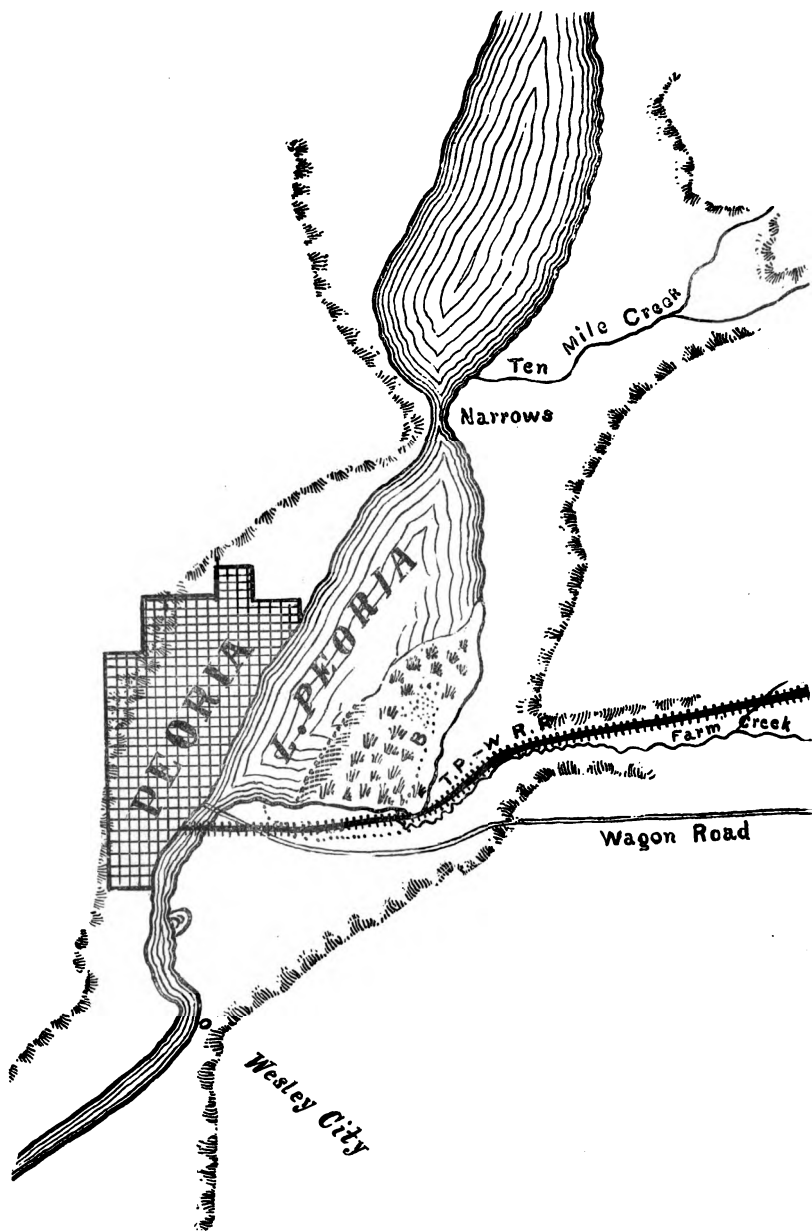
Whatever filling up of the bed of Lake Peoria has been done is the work of Farm Creek. In the high water of spring some silt is, of course, brought down from the upper Illinois, but at least an equal quantity is carried off by the Illinois River below, but generally the upper lake acts as a settling reservoir, and the water which flows through the narrows is comparatively clear. That the upper lake does act as a settling reservoir appears from the fact that no shoaling of the lower lake in its upper portion has been discovered since soundings have been made.

Prior to 1867, Farm Creek ran into the Illinois River through a channel shown by the dotted line in Map No. 1. Its point of *debouchement* into the river varied, but in general it sought the larger stream below the outlet of the lake.

In 1867 the Toledo, Peoria and Wabash Railroad was built. In that year, or afterwards, Farm Creek abandoned its old channel, and turning directly north emptied its waters into the lake.

The lake at that time extended in a line nearly east and west about two miles, and in the channel (500 to 1,000 feet from the Peoria shore) was twelve feet deep at low water. The lake deepened rapidly on the Peoria side, and very gradually on the Tazewell County or east side.

When Farm Creek turned its current directly into Peoria Lake, its waters were brought to rest at once and laid down their burden of sand and soil. A sand-spit formed at the mouth of the creek at the western or down-stream side. This sand-spit (shown in Map No. 2) extended northeast, and year by year grew longer and broader. As it broadened, the mouth of the creek shifted eastward. The creek piled up its sediment on the eastern side of the spit and rapidly filled that portion of the lake. In 1875 a fringe of willows appeared upon the spit, and by 1877 the whole of the newly made land east of the spit was covered with willows and cottonwoods. By this time the creek had crowded itself eastward until it ran close to the original Tazewell shore northward for a mile or more (dotted line B, Map No. 2). All the intervening space between the spit and the



Tazewell shore was now dry land at low water and covered by a dense growth of vegetation, which at high water sifted out whatever detritus was brought down by the creek, and thus raised the surface of the land still more.

In March, 1878, the creek filled its bed (B) and tore a channel for itself through the land it had produced, and running along the original south shore line emptied itself into the lake near the outlet.

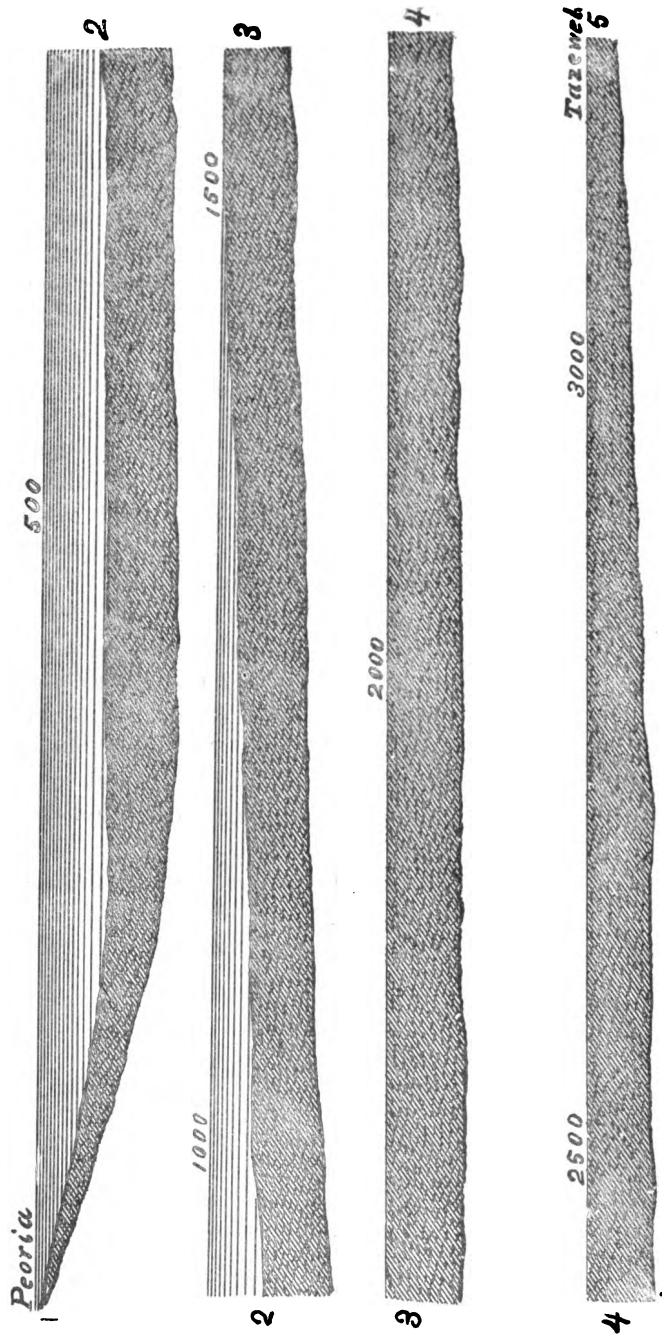
In ten years time it had filled up the whole southeastern corner of the lake, reducing the width thereof at that place from two miles to 1,450 feet, and covering the bottom of one-third of the lake with six feet of mud.

In 1878 the citizens of Peoria had become so alarmed at the threatened destruction of their beautiful lake that they cleared out the original channel of Farm Creek and turned its waters into the Illinois below their city. A large portion of the lake has been hopelessly lost, however, and a miasmatic marsh, flooded in high water, lies over against that pretty town. About 1,000 acres have been taken from the lake and added to Tazewell County.

Besides this, the whole southern portion of the lake has shoaled from thirteen feet to less than six feet in the deepest part, and elsewhere in proportion. Diagram No. 3 shows a cross-section of the lake at 1,750 feet above the outlet. The section starts from the Peoria shore and runs eastward 3,200 feet. The imagination may protract the section. The lower line shows the bottom of the lake in 1867; the light shading shows the bottom in 1877 and the extent of water surface at low water.

Beginning at the wagon bridge at the outlet of the lake, a series of soundings in the deepest water was taken in 1867 by Col. D. C. Jenné. The following table will show the shoaling in 1877:

250 feet above bridge.....	1867. feet.	1877. feet.
500 " " "	7. "	6. "
1,000 " " "	7. "	5. 9 "
1,500 " " "	7. "	5.45 "
2,000 " " "	13.3 "	5. "
2,500 " " "	12. "	4.45 "
3,000 " " "	12. "	4. 6 "
3,500 " " "	12.5 "	5. "
4,000 " " "	12. "	5.68 "
4,500 " " "	11. "	6. 5 "
5,000 " " "	13.5 "	7. "
5,500 " " "	14. "	7. "
6,000 " " "	11. "	8. "
6,500 " " "	11. "	9. "
7,000 " " "	11. "	9. "
7,500 " " "	11. "	9. "
10,000 " " "	11. "	10. "
10,500 " " "	11. "	11. "



Soundings above this point show no especial change between 1867 and 1877.

From the above table it appears that the influence of Farm Creek ceased at about two miles up the lake.

A very moderate estimate will give 80,000,000 cubic feet of sediment brought down by this creek in ten years.

Now let us examine the active little stream which has done this work.

Farm Creek is fifty feet wide and three feet deep when full, which is only in freshets. In dry weather it shrinks so as to become almost invisible under its bed. It is difficult, therefore, accurately to determine its discharge, but we may approximate it.

It drains 44 square miles. Upon that country the rainfall averages 42 inches annually. This gives 4,200,000,000 cubic feet of water per annum. The creek cannot, therefore, discharge more than that amount. If we take 75 per cent. of the rainfall as the discharge, which is the usual estimate for the small tributaries of the Mississippi, we will have about 3,000,000,000 cubic feet of water brought down by this stream.

Observation confirms this estimate. When the creek was full it ran 300 feet per minute. When 11 feet wide it was 5 inches deep, and ran 98 feet per minute. When 7 feet wide it was 4 inches deep, and ran 100 feet per minute (having just then shortened its length by a mile).

Averaging all the observations of 1877-8, I find the theoretical estimate of 3,000,000,000 feet of water discharged per annum to be about correct. More than half of this discharge occurred in thirty days.

Thirty billions of cubic feet of water (ten years' flow) have, therefore, moved 80,000,000 cubic feet of sand and mud. The proportion of water to sediment is as 375 to 1.

This is a large proportion of sediment.

The River Po is said to move 1 proportion of sediment to 300 of water.									
"	Ganges		1	"	"	"	"	1,000	"
"	Mississippi	from	1	"	"	"	"	528	"
		to	1	"	"	"	"	3,000	"

Not all of the sediment moved by Farm Creek was held in suspension. I think that less than three-eighths was properly in suspension. The greater portion was rolled along the bottom. My crude experiments showed a proportion of 1,100 parts of water to one of sediment. This would account for but 30,000,000 of the

80,000,000 of deposit. The remaining 50,000,000 have been pushed or rolled along the bottom.

One day I was witness of this pushing process. I had anchored my boat in the mouth of Farm Creek upon a sand shoal. The water was perfectly clear; nothing was held in suspension. But I observed that the whole bottom seemed alive. Rolling over each other, tumbling this way and that, but always down stream, leaping sometimes six inches at once, the grains of sand were all moving into the lake. This was in dry weather and the water was low — the current not more than 100 feet a minute. I saw then how water, while holding nothing in suspension, can yet effect important movements in the particles of its bed. This pushing process increases in energy, of course, when the stream becomes a torrent in floods, but it is a process which can go on in any flowing stream. Being unintermitted, the aggregate of its effect must be great. I do not hesitate to express my conviction that five-eighths of the work done by Farm Creek was done by the rolling of sand and mud along the bottom.

Farm Creek presents no unusual conditions. It is an ordinary stream flowing through prairie soil. There are thousands of such streams in the valley of the Mississippi. I apprehend that every one of them does as much in the way of erosion and land formation as Farm Creek, and that many changes which hitherto have been supposed to be the work of vast cycles of time have been the work of but a few years.

The above observations may be of service in solving the historic problem of La Salle's fort Crève Cœur.

On the 1st of January, 1680, La Salle landed at an Indian village on Peoria Lake. Shortly afterward he began the erection of a palisaded fort "on the left bank of the lake at its lower extremity."

The record both of himself and Father Hennepin, the priest who accompanied the explorers, are definite in giving the location as on the "left bank" and at the southern part of the lake. It is also stated that the fort was on a hill and commanded the approach by water up and down. This fort was named Crève Cœur, from the misfortunes which befel the heroic chevalier.

Historians have been at a loss to determine the site of this fort. By examining the accompanying maps it will be seen that there is no high ground anywhere along the southern shore of Lake Peoria. On the east, west and south the bluffs are a mile or more from the shore of the lake. At the northwest corner, overlooking the narrows, the bluffs do touch the lake, and a hill rises abruptly 100 feet

and more. Some have supposed that this must have been the site of Crève Cœur, and that the explorers must have meant the southern extremity of the upper lake. But unfortunately this point is on the *right* side of the stream and not on the *left*. Nothing can justify the supposition that La Salle, who had traversed the Illinois River from its source, did not know which way the water flowed. We must look on the opposite bank for the site of Crève Cœur.

One place answers the greater part of the conditions. It is a point two miles down the river at Wesley City. Here the bluff touches the river; an uninterrupted view is had up and down stream; it is on the *left* bank, and several hills suitable for defensive works against indians still exist. This position answers so well to the description given by La Salle that most historians have settled upon it as the site of Crève Cœur. But it is not on the lake; it is more than two miles south. The country between it and the lake is heavily wooded. Part of the land is low, but several hundred acres are in good farms. Various conjectures have been ventured to reconcile this location at Wesley with La Salle's statement that his fort was on the lake, such as that "two miles was so short a distance that La Salle would not mention it," or that "the river happened to be very high so that the limits of the lake were not well defined." But these conjectures are not satisfactory.

The true explanation appears to me to be that in La Salle's day Lake Peoria extended as far south as Wesley City. The whole intervening land, two and a half miles long by one mile broad, has been made by Farm Creek in the two hundred years since the French occupation.

Vol. I.

No. III.

BULLETIN
OF THE
CHICAGO ACADEMY OF SCIENCES.

LIST OF BATRACHIA AND REPTILIA
OF
ILLINOIS.

BY N. S. DAVIS, Jr., AND F. L. RICE.

C.
CHICAGO:

C. H. BLAKELY & CO., PRINTERS, 68 & 70 WABASH AVENUE.

1883.

BULLETIN

OF THE

CHICAGO ACADEMY OF SCIENCES.

LIST OF BATRACHIA AND REPTILIA OF ILLINOIS.

BY N. S. DAVIS, JR., AND F. L. RICE.

The greater part of the following list was prepared for publication in 1876. The facts were collected by the authors and Mr. E. W. Nelson, to whom belongs equal credit in preparing the larger portion of the list. Since then, however, many additions have been made. A considerable number of species noticed below have not before been recorded as coming from this section of the country. There are quite a number also that, from their known distribution, we may expect to find in Illinois, but they have been excluded from the present list, as no well authenticated specimens from the State have come under the authors' notice. We wish to express thanks especially to Mr. Robert Ridgeway, Dr. P. R. Hoy, Prof. F. Stein and Dr. Schenck, for local lists which they have furnished us. The present list includes species and sub-species of—

Ophidia	54
Lacertilia	6
Testudinata.....	14
Total Reptilia.....	74
Trachystomata.....	1
Proteida	1
Caducibranchiata	17
Anoura.....	13
Total Batrachia	32
Total Reptilia and Batrachia	106

From this it is seen that, nearly one-third of all the Reptilia and Batrachia of the United States are included in the fauna of Illinois.

BATRACHIA OF ILLINOIS.

TRACHYSTOMATA.

SIRENIDÆ.

1. *Siren lacertina*, Linn. Great Siren. Found throughout the Austroriparian region. A specimen in the collection of the Northwestern University was obtained in Northern Illinois.

PROTEIDA.

PROTEIDÆ.

2. *Necturus lateralis*, Say. Mud-puppy or Water-dog. Exceedingly abundant in Lake Michigan; found also in the Mississippi and other rivers throughout the State.

CADUCIBRANCHIATA.

MENOPOMIDÆ.

3. *Menopoma allegheniense*, Harl. Hellbender. Found in the Mississippi and its tributaries.

AMBLYSTOMIDÆ.

4. *Amblystoma talpoideum*, Holb. Mole Salamander. Found in the extreme Southern portion of the State.
5. *Amblystoma opacum*, Graven. Opaque Salamander. Abundant throughout the State.
6. *Amblystoma punctatum*, Linn. Large Spotted Salamander. Common in all parts of the State.
7. *Amblystoma tigrinum*, Green. Tiger Salamander. Exceedingly abundant everywhere.
8. *Amblystoma jeffersonianum*, Gr. sub-sp. *laterale*, Hall. Jefferson's Salamander. Found in the extreme Northern portion of the State.
9. *Amblystoma jeffersonianum*, Gr. sub-sp. *platineum*, Cope. A specimen in the collection of the Smithsonian Institution extends the Western range of this sub-species into Illinois.

PLETHODONTIDÆ.

10. *Hemidactylium scutatum*, Schl. Four-toed Salamander. Found throughout the State.
11. *Plethodon cinereus*, Gr. sub-sp. *cinereus*. Gr. Red-backed Salamander.

12. *Plethodon cinereus*, Gr. sub-sp. *erythronotus*. Gr. Both sub-species of this species are found in all parts of the State.
13. *Plethodon glutinosus*, Gr. Viscid Salamander. Common throughout the State.
14. *Spelerpes bilineatus*, Gr. Two-striped Salamander. Found throughout the State.
15. *Spelerper longicaudus*, Gr. Cave Salamander. From all parts of the State.
16. *Spelerpes ruber*, Daud.; sub-sp. *ruber*, Daud. Red Triton. Found throughout the State.

DESMOGNATHIDÆ.

17. *Desmognathus fusca*, Raf.; sub-sp. *fusca*, Raf. Dusky Salamander. Found in all portions of the State.
18. *Desmognathus nigra*, Gr. Black Salamander. A specimen in the collection of the Smithsonian Institution was found in Cook Co., Illinois.

PLEURODELIDÆ.

19. *Diemictylus miniatus*, Raf.; sub-sp. *miniatus*, Raf. Red Evet. Common throughout the State.
20. *Diemictylus miniatus*, Raf.; sub-sp. *viridescens*, Raf. Spotted Evet. Common in all parts of the State.

ANOURA.

BUFONIDÆ.

21. *Bufo lentiginosus*, Shaw; sub-sp. *americanus*, Le Conte. Common toad. Exceedingly abundant everywhere.

ENGYSTOMIDÆ.

22. *Engystoma carolinense*, Holb. Found in the extreme Southern part of the State.

HYLIDÆ.

23. *Acris gryllus*, Le C.; sub-sp. *gryllus*, Le C. Cricket Frog. From Southern Illinois.
24. *Acris gryllus*, Le C.; sub-sp. *crepitans*, Bd. Northern Cricket Frog. From the central and Northern part of the State.
25. *Chorophilus triseriatus*, Wied.; sub-sp. *triseriatus*, Wied. Tree Frog. Abundant in the Northern portion of the State.
26. *Hyla squirella*, Daud. Squirrel Frog. From Southern Illinois.

27. *Hyla pickeringi*, Holb. Pickering's Tree Toad. Not uncommon in the Northern portion of the State.
28. *Hyla versicolor*, Le C. Common Tree Toad. Abundant throughout the State.

RANIDÆ.

29. *Rana halecina*, Kal. Common Frog. Exceedingly abundant in all parts of the State. If the sub-species *halecina* and *berlandieri* are good, they are both found in the State.
30. *Rana palustris*, Le C. Pickerel Frog. Common throughout the State.
31. *Rana clamitans*, Merr. Green or Spring Frog. Abundant throughout the State.
32. *Rana catesbiana*, Shaw. Bull Frog. Common everywhere in the State.
33. *Rana temporaria*, Linn; sub-sp. *silvatica*, Le C. Found in all portions of the State. Abundant in the Northern part.
34. *Rana areolata*, B. & G.; sub-sp. *circulosa*. Ringed Frog. Specimens in the Smithsonian collections were obtained by Robert Kennicott in Northern Illinois.

REPTILIA OF ILLINOIS.

OPHIDIA.

CROTALIDÆ.

1. *Crotalus horridus*, Linn. Banded or Northern Rattle Snake. Found throughout the State. Abundant in certain localities.
2. *Caudisoma tergemina*, Say. Massassauga. Prairie Rattle Snake. Found in all portions of the State except "the heavily timbered regions of the South."*, Formerly abundant in the Northern portion, but less common at present.
3. *Ancistrodon piscivorus*, Lac.; sub-sp. *piscivorus*, Lac. Water Moccasin. Found in the Southern part of the State.
4. *Ancistrodon contortrix*, Linn. Copper-head. Cotton-mouth. Found occasionally in all parts of the State.

*Fide Kennicott. List of Rep. and Batr. of Cook Co., 1858. Transactions of Illinois Agricultural Society.

COLUBRIDÆ.

5. *Carphophiops heleneæ*, Kenn. Helen Tennison's Snake. From Southern Illinois.
6. *Carphophiops amoenus*, Say. Ground Snake. Found throughout the State, but not abundant.
7. *Carphophiops vermis*, Kenn. Worm Snake. From the Southern portion.
8. *Virginia valeriæ*, B. & G. Valeria Blaney's Snake. Southern Illinois.
9. *Virginia elegans*, Kenn. Kennicott's Brown Snake. Southern Illinois.
10. *Haldea striatula*, Linn. Brown Snake. From the Southern portions of the State.
11. *Abastor erythrogrammus*, Daud. Red-lined Snake. From Southern Illinois.
12. *Farancia abacura*, Holb. Red-bellied Horn Snake. Found in Southern Illinois.
13. *Oseola elapsoides*, Holb. Scarlet Snake. Southern Illinois.
14. *Ophibolus doliatus*, Linn; sub-sp. *coccineus*, Schl. Red King Snake. Southern Illinois.
15. *Ophibolus doliatus*, Linn; sub-sp. *doliatus*, Linn. Corn Snake. Southern part of the State.
16. *Ophibolus doliatus*, Linn; var. *triangulus*, Borè. Milk Snake or Spotted Adder. Abundant throughout the State.
17. *Ophibolus getulus*, Linn; var. *Sayi*,* Holb. King Snake. Found in all parts of the State.
18. *Ophibolus rhombomaculatus*, Holb. Southern Illinois.
19. *Ophibolus calligaster*, Say. Kennicott's Chain Snake. Southern part of State.
20. *Diadophis punctatus*, Linn; sub-sp. *punctatus*, Linn. Ring-necked Snake. Throughout the State. Not common.
21. *Diadophis punctatus*, Linn; sub-sp. *amabilis*, B. & G. Southern Illinois.
22. *Diadophis arnyi*, Kenn. Arny's Ring-necked Snake. Southern Illinois.
23. *Cyclophis vernalis*, De K. Green or Grass Snake. Abundant in the Northern part of the State; rare in the Southern.
24. *Cyclophis æstivus*, Linn. Summer Green Snake. From Southern Illinois.
25. *Coluber emoryi*, B. & G. Emory's Racer. Found in the Southern portion of the State.
26. *Coluber lindheimeri*, B. & G. Southern Illinois.

*This species has been taken in Wisconsin by Dr. P. R. Hoy, of Racine.

27. *Coluber vulpinus*, B. & G. Fox Snake. Common in Northern Illinois; probably found throughout the State.
28. *Coluber obsoletus*, Say; sub-sp. *obsoletus*, Say. Pilot Snake. Throughout the State.
29. *Coluber obsoletus*, Say; sub-sp. *confinis*, B. & G. Racer. Southern Illinois.
30. *Coluber guttatus*, Linn. In the Smithsonian collection there is a specimen from Mt. Carmel, Ill.
31. *Ptyophis sayi*, Schl.; sub-sp. *sayi*, Schl. Western Pine Snake. Found throughout the State. Not common.
32. *Bascanion constrictor*, Linn; sub-sp. *constrictor*, Linn. Black Snake. Blue Racer. Abundant throughout the State.
33. *Eutzenia saurita*, Linn. Riband Snake. Swift Garter Snake. Throughout the State.
34. *Eutzenia faireyi*, B. & G. Fairies' Garter Snake. Occurs throughout the State.
35. *Eutzenia proxima*, Say. Say's Garter Snake. Found in all parts of the State; common in the Northern portion.
36. *Eutzenia radix*, B. & G. Hoy's Garter Snake. Very abundant in the Northern part of the State.
37. *Eutzenia vagrans*, B. & G.; sub-sp. *vagrans*, B. & G. Spotted Riband Snake. A typical specimen of this species was collected near Chicago by Mr. E. W. Nelson in 1874.
38. *Eutzenia sirtalis*, Linn; sub-sp. *dorsalis*, B. & G. Common Striped Snake. Abundant in all parts of the State.
39. *Eutzenia sirtalis*, Linn; sub-sp. *sirtalis*, Linn. Common Garter Snake. Exceedingly common throughout the State.
40. *Eutzenia sirtalis*, Linn; sub-sp. *parietalis*, Say. Red-spotted Garter Snake. "Occurs plentifully in the Wabash Valley."* Has also been taken in the central portion of the State.
41. *Eutzenia sirtalis*, Linn; sub-sp. *obscura*, Cope. Common in Northern Illinois.
42. *Storeria occipitomaculata*, Storer. Red-bellied Snake. Common in all parts of the State.
43. *Storeria dekayi*, Holb. De Kay's Brown Snake. Found throughout the State; abundant in the Northern portion.
44. *Tropidoclonium kirtlandi*, Kenn. Cora Kennicott's Snake. Rare in Northern Illinois; abundant in central.
45. *Tropidonotus grahami*, B. & G. Graham's Snake. Found throughout the State; less abundant than formerly in the Northern portion.
46. *Tropidonotus leberis*, Linn. Leather Snake. Occurs throughout the State; abundant in the Northern portion.

*Fide R. Ridgeway.

47. *Tropidonotus fasciatus*, Linn. Fasciated Water Snake. Southern Illinois.
48. *Tropidonotus sipedon*, Linn; sub-sp. *sipedon*, Linn. Water Snake. Abundant in all parts of the State.
49. *Tropidonotus sipedon*, Linn; sub-sp. *woodhousei*, B. & G. Found throughout the State.
50. *Tropidonotus sipedon*, Linn; sub-sp. *erythrogaster*, Sh. Red-bellied Water Snake. Found throughout the State.
51. *Tropidonotus rhombifer*, Hall. Throughout the State.
52. *Tropidonotus cyclopium*, D. & B. Southern Illinois.
53. *Heterodon platyrhinus*, Latr. Spreading Adder. Abundant in all parts of the State.
54. *Heterodon simus*, Linn; sub-sp. *simus*, Linn. Hog-nosed Snake. Occurs throughout the State.*

LACERTILIA.

SCINCIDÆ.

1. *Oligosoma laterale*, Say. Ground Lizard. Southern Illinois.
2. *Eumeces fasciatus*, Linn. Blue-tailed Lizard. Found throughout the State; especially common in the Southern portion.
3. *Eumeces obsoletus*, B. & G. Central and Southern Illinois.

TEIDÆ.

4. *Cnemidophorus sexlineatus*, Linn. Six-lined Lizard. Found in all parts of the State, and extends Northward into Wisconsin.†

ANGUIDÆ.

5. *Opheosaurus ventralis*, Daud. Glass Snake. Found throughout the State. Abundant in the central part; formerly common in the Northern, but rare at present. Has been taken in Southern Wisconsin.‡

IGUANIDÆ.

6. *Sceloporus undulatus*, Harl.; sub-sp. *undulatus*, Harl. Swift Lizard. Taken throughout the State; abundant in some localities.

* Dr. P. R. Hoy has taken this species in Western Wisconsin.

† Wisconsin. Fide Dr. P. R. Hoy.

‡ Wisconsin. Fide Dr. P. R. Hoy.

TESTUDINATA.

TRIONYCHIDÆ.

1. *Amyda mutica*, Les. Leathery Turtle. Found in the Mississippi and other rivers of the State. Has been taken in Lake Michigan.
2. *Aspionectes spinifer*, Les. Common Soft-shelled Turtle. Found in Lake Michigan; abundant in many of the rivers of the State.

CHELYDRIDÆ.

3. *Chelydra serpentina*, Linn. Common Snapping Turtle. Very common in all localities.
4. *Macrochelys lactina*, Schw. Alligator, or Mississippi Snapper. Southern Illinois. Has been taken in the Mississippi as far North as Wisconsin.*

CINOSTERNIDÆ.

5. *Aromochelys odoratus*, Latr. Musk Turtle. Stink Pot. Throughout the State.
6. *Aromochelys carinatus*, Gray. Has been taken as far north as Lake County.

EMYDIDÆ.

7. *Pseudemys hieroglyphica*, Holb. Southern Illinois.
8. *Pseudemys troosti*, Holb. Yellow-bellied Terrapin. Southern part of the State.
9. *Pseudemys elegans*, Wied. Southern Illinois.
10. *Malacoclemmys geographicus*, Les. Map Turtle. Found throughout the State.
11. *Malacoclemmys pseudo-geographicus*, Holb. Le Sueur's Map Turtle. Found in all parts of the State.
12. *Chrysemys picta*, Herm. Painted Turtle. Found throughout the State; abundant in the Northern portion.
13. *Emys meleagris*, Shaw. Blanding's Turtle. Abundant in Northern Illinois.
14. *Cistudo clausa*, Gm. Common Box Turtle. Throughout the State.

*Wisconsin. Vide Dr. P. R. Hoy.

10,121
Oct. 4, 1884.

27

240.8

Vol. I.

No. IV.

BULLETIN
OF THE
CHICAGO ACADEMY OF SCIENCES.

REPORT OF THE COMMITTEE ON THE
MICROSCOPIC ORGANISMS IN THE BOWLDER
CLAYS OF CHICAGO AND VICINITY.

H. A. JOHNSON, M. D.,
B. W. THOMAS, F. R. M. S., } *Committee.*

CHICAGO:
JOHN MORRIS, SUCCESSOR TO CULVER, PAGE, HOYNE & CO., PRINTERS,
1884.

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H. A. JOHNSON, M. D., B. W. THOMAS, F. R. M. S., Committee.

At the regular monthly meeting of the Chicago Academy of Sciences, held Tuesday evening, January 15, 1884, the following paper was submitted by the special committee to which had been assigned the task of investigating the "boulder clays" underlying this city:

While the lake tunnel, for the purpose of supplying the city of Chicago with water from Lake Michigan, was in process of construction, specimens of the clay through which the excavation was made were subjected to microscopical examination by several members of the Academy, for the purpose of determining the presence or absence of organic remains. This was during the years 1865 to 1867. The result of these examinations was the discovery by the members of the present committee and others of a disc, varying from $\frac{1}{85}$ part of an inch to $\frac{1}{250}$ of an inch in diameter. They were yellow in color, apparently flat or concavo-concave, and were unknown to any paleontologist to whom they were submitted. On the completion of the lake tunnel, large numbers of the same discs were frequently observed in the precipitate from the city water supply. Slides were sent to New York and to London, but without obtaining any information on the matter. The subject was then allowed to rest, and nothing further was done toward ascertaining their character, distribution, or affinities till the last summer, when an examination of clays collected by an exploring party of the Academy from the high bluffs on the shore of Lake Michigan, twenty miles north of this city, revealed the presence of discs identical in character with those found in the tunnel clays and in the precipitate from the lake water. As a result of this discovery, the present committee was formed and instructed to more thoroughly investigate the microscopic organisms of our boulder clay.

In the performance of this duty, the committee have examined many specimens of clay and their contents of fragments of shale, etc., from this vicinity, and also of clay and shale from the Carboniferous deposits of Illinois and other States. Slides from these clays and shales, as well as from our own deposits, and from our city water supply, have been prepared and are under the microscopes for examination at the close of the paper.

The committee have some additional information in regard to these discs, but before entering upon the results of their own study, they beg to call the attention of the Academy to the literature of the subject, for, since 1867, there has been created a literature.

In 1871, Prof. J. W. Dawson, of Montreal, described a form found in the shales at Kettle Point, Lake Huron, known as the Erian formation, and which has been referred to the Marcellus shales of New York. The descriptions of Prof. Dawson apply fairly well to the bodies found here and first noticed in 1865-66-67. They are evidently the same or belong to the same family. Since Dr. Dawson's article these bodies have been found in widely distant localities, but always in shales of the upper Devonian age, or in close relation to them, the only exception being, so far as known to the committee, the clays of Chicago and vicinity. With the same exception they have always been found *in situ*—that is, in deposits which have not been transported or disturbed. These microscopic forms, found in abundance in our boulder clay and in the city water supply, testify to the former existence of the oil-bearing shales in areas from which denudation has now entirely removed them.

Prof. Dawson described these discs as brownish in color, in his paper published in 1871. He considered them as spore cases or *Macrospores* of some *Acrogenous* plant. This paper was published in the *American Journal of Science* for April, 1871. They are there described as "flattened, disc-like bodies, slightly papillate externally, and with a minute point of attachment at one side and sometimes with a slit more or less gaping at the other. Viewed under the microscope as transparent objects, they appear yellow, like amber, and show little structure except that the walls can be distinguished from the internal cavity, and the latter is seen in places to contain patches of granular or flocculent matter."

The shale in which these discs were found contained bituminous matter and burned with much flame. There were also other small particles which Prof. Dawson believed to be stems of a species of *Calamites*. The description of these stems may be accepted as applying to similar particles found adhering to or associated with the discs as noticed by us in 1865-67, and since. What these discs are seems to be yet a question. Prof. Dawson appears to have given no further attention to the subject till 1882, when Prof. Edward Orton, of Columbus, Ohio, reported the discovery of similar bodies in the Erian and lower Carboniferous shales of Ohio. Prof. Orton published his discovery in the transactions of the *American Association for the Advance-*

ment of Sciences for that year. At the same meeting of the association, in the discussion of Prof. Orton's paper, Prof. Williams, of Cornell University, mentioned that he had found similar bodies in the Hamilton shales of New York, and that they were associated with a curiously pinnated plant, a species of *Ptilophyton*.

Prof. J. M. Clarke, of Northampton, Mass., subsequently reported the presence of similar bodies in the Genesee shales, and also from the Carboniferous limestones. All these reports, however, did not enable Prof. Dawson to definitely assign to this form its proper place in the flora of this early age. In March, 1883, Mr. Orville Derby, of the geological survey of Brazil, sent Prof. Dawson specimens from the Erian formation of that country, and which contained forms similar to those which had previously been discovered in North America. It appears that the late Prof. Hart had previously reported specimens which were by him assigned to the Carboniferous age, but which Prof. Dawson was inclined to think must belong to the upper Devonian. Prof. Dawson has given provisionally to the South American varieties the name of *Sporangites Braziliensis*, and to the North American forms the name of *Sporangites Bilobatus*, or *Huronensis*, and associates them both with the Acrogenous plants of the Devonian formation.

Prof. Orton's paper, in the transaction of the American Association, discusses in more detail the conditions under which these forms are found in Ohio. They are distributed throughout the upper Devonian formations and through the immense thickness of these deposits, in some places not less than 1000 feet. They do not, however, present the same characteristics in every horizon of this formation. They vary in size and in other respects, which leads Prof. Orton to think there are grounds for separating them into several species. What these differences are except size he does not state. His description may in the main be taken for the discs found in our own clays.



MACROSPORES FROM THE CHICAGO TUNNEL CLAYS AND CITY WATER-SUPPLY.

We have, however, none so large as those discovered by Prof. Orton. Our largest forms are not more than $\frac{1}{85}$ of an inch in diameter, and our smallest about $\frac{1}{250}$ of an inch. We have two and possibly more varieties. One has a well-marked ledge or zone around it, and extending perhaps one-eighth of the way across it. Within this are the spines noted below. Others have no such markings, and do not as a rule have spines, and while some are in color a very light yellow or amber, and almost transparent, others are of a dark reddish brown and almost opaque. Whether these differences are sufficient to justify their separation into different species, seems to be at present doubtful. So far no forms have been met with by either of us having anything like a stem or point of attachment. Nor have we found any of the spherical or oval sacs which were contained in the collections of Mr. Derby.

There are found here, however, what we believe have not been found elsewhere—namely, on many of the discs, are well-marked *spines*. These spines, as a rule, occupy a central portion, the diameter of which is about three-fourths of the entire breadth of the disc, but in some instances they cover the entire surface. Along with these discs are, in quite large quantities, broken pieces of what seem to have been leaves; perhaps pinnate in form. In addition to these forms, dark globular masses, which seem to be, possibly, spores or microspores, are frequently seen on the discs, and also scattered among them, and are—at least, in some cases—also contained within the substance of the discs. They are regular in form, and vary in size from $\frac{1}{8000}$ to $\frac{1}{8000}$ of an inch in diameter. They are evidently organized, for in some cases there is seen a reticulum or net-work within the dark substance of the body. With these microspores, if such they are, are also masses of dark matter that, at least in some cases, are made up either of these globular forms alone, or of these and other organic material, such as the stems described by both Prof. Dawson and Prof. Orton. The clay beneath the city of Chicago and in the vicinity is full of boulders of various sizes, from that of a walnut, up to several cubic yards, and on many of these boulders are well-defined ice markings. Some of the smaller boulders are shale, which has never been ground down, and in these unchanged pieces we also find frequently large numbers of discs. These masses of shale, so far as we can ascertain, are identical with the shales of the upper Devonian formation, and, like the black shales of Ohio, burn with a clear, bright flame, giving out a strong petroleum odor.

It will be seen that the discs are evidently not the product of their present location. They have been in some far-off age imbedded in the shales, and subsequently these shale deposits have been broken up and most of it ground to clay, and with other material constituting the "Boulder Clays" have been redeposited beneath the lake and the adjacent shores. They are now undergoing another dispersion, for they are being washed from their present position in the Chicago clays and are mixed with the sands and alluvium to be carried by the currents and winds to some new resting place. Conse-

quently our water-supply is now full of these products of probably some millions of years ago. And with the aid of the Microscope, they now testify that in some remote period of time, and amid very different surroundings, an abundant marine vegetation was being produced which has been preserved to our own day. On the tables are Microscopes and slides which illustrate how abundantly they exist in the clays of our "boulder drift," in the Black Shales of Ohio, and in the water from our hydrants.

Prof. Orton has called attention to the great quantities of resinous matter contained in these shales. If a piece containing these discs is held in the flame of a spirit lamp, the discs burn like resin, and leave the pit or mold in the rock which they have occupied distinctly marked. In some localities, these shales have been distilled, and one ton of the black Ohio shales has been made to yield twenty gallons of oil. This has been done as a business, and we understand has been made to pay.

Prof. Orton suggests that these bodies are in part at least the origin of the petroleum found so abundantly in or near the horizon of the Devonian formations in Pennsylvania and other localities constituting the oil regions.

It seems not improbable that this hypothesis is correct. These plants must have been very abundant through a wide extent of territory and continuing through a long period of time. The study of their distribution is not yet complete, but the Committee beg to call attention to the fact that these organisms were, so far as known, first discovered here in the tunnel clays, and secondly they have never been found elsewhere except *in situ*.

NOTE BY B. W. THOMAS.

Since the reading of the report of your Committee on the "Microscopical Organisms found by them in the Boulder Clays underlying Chicago and vicinity," at the January meeting of the Academy, in the absence from the city of Dr. Johnson, I have individually continued the examination of drift material in this vicinity and from other parts of the Northwest.

So far as examined, all of the clays on the west shore of Lake Michigan, from Kenosha, Wis., on the north, to the Indiana State line on the south, contain an abundance of the *Macrospores* referred to in that paper, both free in the clay and *in situ* in fragments of shale. These clays range from some seventy feet above the level of Lake Michigan to (I am advised) over 200 feet below its surface.

In the examination of clays from other localities, I get some very unexpected results. In several specimens of "Blue Boulder Clay" kindly sent by Prof. N. H. Winchell, State Geologist of Minnesota, as "taken from fourteen to twenty-one feet below the surface when digging a well at Litchfield, Meeker County, Central Minnesota," I find an abundance and several species, of fossil *Rhizopods*, fragments of *Diatoms*, several species of well-

preserved and characteristic *Foraminifera*, among others *Textularia globosa*, *al* *Rotalia globosa* and *Globigerina*, as identified by Prof. Joseph Leidy, who advises me that these forms are yet living and common in the Atlantic Ocean. A disc form with crenate margin, resembling the lorica of an infusorian, is quite abundant, and large quantities of forms and fragments not yet identified. From the great similarity of some of the contents of the Minnesota clays with what we find associated with the macrospores in the Chicago clays, I am quite confident that we shall yet find in the Minnesota clays, mingled with *Rhizopods*, etc., of the *Cretaceous* formation, the shale an macrospores of the *Devonian*.

All of the forms yet identified, both in the Chicago clays and in those from Minnesota, are undoubtedly of marine origin.

In a specimen of clay from the lower drift deposit, 135 feet below the surface, kindly sent to me from Bloomington, Ill., by Dr. G. W. Mason (there are two well-defined deposits in that vicinity, separated by a stratum of black soil and quantities of well preserved timber, with stumps of trees apparently in their natural position), I find discs similar in every way to the macrospores found here, except that they are smaller in size.

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BULLETIN

—OF THE—

CHICAGO ACADEMY OF SCIENCES.

A PAPER ON

The Northern Pitcher-Plant or the Side-saddle Flower,
Sarracenia purpurea, L.

By W. K. HIGLEY.

LAKE GENEVA, WIS.,
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1885.

BULLETIN

—OF THE—

CHICAGO ACADEMY OF SCIENCES.

The Northern Pitcher Plant or the Side-saddle Flower, *Sarracenia purpurea*, L.

By W. K. HIGLEY, Seminary, Lake Geneva, Wisconsin.

That insects are of great use in the vegetable economy is a subject of much interest to many scientific minds of the present day, causing many investigations resulting in experiments that are leading us into a deeper and truer knowledge of the physiology of plants.

These investigations are transforming many theories into facts; many mere fancies into realities; many of the so-called "freaks of nature," of the older writers, into useful adaptations for aiding in the development of the plant. It is now obvious, even to the slack and unscientific observer of nature's laws and methods of work, that the insect world is necessary for the proper growth and propagation of many species belonging to the vegetable kingdom.

It is well known to the intelligent agriculturist that many of the plants used in our economy could not even mature their seeds unless aided by insects, notably the hive bees. The beautiful orchid family is a grand illustration of the usefulness of insects in fertilization. Dr. Charles Darwin has shown that each part of the flower is adapted to this end. It seems as if, in this family, nature truly abhors self-fertilization and in some species, though giving the plant all the parts of a hermaphrodite, yet arranging them so that only an insect can bring about the proper relations for propagation. Our melon, pumpkin, squash, cucumber and gourd plants are also worthy of note in this connection. "The flowers" of these "are each furnished with a long or rather deep corolla and the plants often lie flat on the ground where the leaves cover the flowers from the action of the wind. Bees and other insects are the necessary agents in crossing the flowers", for they are either diœcious or monœcious, "and to them we are indebted as one of the links in the chain which affords all our gourd-like fruits."

To this division of Entomophilous species belongs the plant under consideration in this paper. All the species of the genus *Sarracenia* are constructed in such a manner that in fertilization they are absolutely helpless without the aid

of insects. The large umbrella-like expansion of the style, which is stigmatic at the termination of the fire rays, completely hides the stamens which are decidedly below it and shielded from the wind.

A still more peculiar use of insects to the vegetable world is that of a food and many plants are specially fitted for catching and using the material of their bodies for nourishment.

Perhaps the most striking of all these plants are the pitcher-plants, some of which throw out a honeyed secretion which, trickling down the wing of the pitcher, forms a baited pathway to attract the unwary insect to the inside of the pitcher.

The genus *Sarracenia*, to which the plant under consideration belongs, is one of the three genera of the order *Sarraceniaceæ*. The species of all the genera are natives of America and chiefly of the United States, the genus *Heliamphora* being a native of Venezuela. Mr. Sereno Watson * makes the following enumeration of the species of the other two genera, *Darlingtonia* and *Sarracenia*:

Darlingtonia Californica, Torr.

Sarracenia Drummondii.

- " *flava*, L.
- " *psittacina*, Mx.
- " *purpurea*, L.
- " *nigra*, Walt.
- " *Sweetii*, D. C.
- " *undulata*, Denie.
- " *variolaris*, Mx.

All the species have root-leaves and excepting the genus *Heliamphora*, have terminal scapes bearing a single flower. The exception has a scape bearing a few flowered raceme. The leaves are all hollow and more or less pitcher-shaped, with a hood at the upper part and a wing, that is often very broad, upon one side.

As to their position in classification, this family† quite closely resembles the poppy family (*Papaveraceæ*), on the one hand, and the water-lily family (*Nymphæaceæ*) on the other. It is related to the former by the character of its petals, numerous stamens and seeds, capsular fruit, copious albumen, etc. It is connected with the latter by nearly the same characters,‡ and also by having all the leaves from the root, a one-flowered scape and more or less aquatic habits. The poppy family differs in habits, juices, in having but two or three sepals and a one-celled ovary. The water-lily family differs in having, usually, numerous petals, in the attachment of the seeds and the sessile stigmas.

By certain analogies the pitcher-plants are closely related to the sundew family (*Droseraceæ*), and the Asiatic pitcher-plant family (*Nepenthaceæ*).

A microscopical study of the minute structure of the families mentioned not only confirms the close relationship existing between them but also adds new facts to those that appear from a study merely of the external characters of their representative species.§

*Bibliographical Index to North America Botany, by Sereno Watson, Smithsonian Miscellaneous collections.

†General System of Botany, LeMaout, and Decaisne. p. 212.

‡The water-lily family in some of its forms has a definite number of stamens.

§Since the writing of this paper Mr. J. F. James has published a very interesting article on "How the Pitcher Plant got its Leaves." (*American Naturalist* Vol. xiv, p. 567.)

After tracing the apparent gradation of adaptability for taking insect food existing between the species of the genera of *Sarraceniaceæ* from the less marked trap and imperfect

Our northern pitcher-plant is, perhaps, the one of greatest interest to the people of the Northern States.

It is by far the most common form of the genus extending in its range over the states east of the Mississippi and north from Florida far into the British Possessions. It is not so elaborate an insect catcher as some of the more southern forms which have already been spoken of as throwing out a honeyed lure which attracts numerous ants, an insect rarely found in our species.

The pitcher leaves (*Ascidia*) of the Side-saddle flower, as well as those of all the family, are evidently phyllodia. They have the parallel venation of petioles acting as blades and the edge is invariably turned toward the sky. The hood may represent the blade of the leaf. The wing forms the greater part of the young leaf.

Inside these pitchers are found hairs, which cover more or less of the inner surface. Those which cover the hood continue to or a little beyond the junction with the tube. Following this area is a smooth surface which extends to near the point where the leaf begins to contract when a patch of less stiff hairs are met with. This time they extend into the narrower portion of the tube. All the hairs point downward.

The position and form of these hairs, especially those on the hood and upper part of the tube and in fact any that may be above the fluid, in the lower part of the leaf, would show that their function, in part at least, is to prevent the escape of any insect that may have entered the tube. The hairs in the lower part of the tube probably act, to some extent, as absorbents of the nitrogenous matter decaying within the leaf. Some acute observers claim that at the end of each hair there is a minute opening, thus allowing the nitrogenous fluid to pass directly into the apical cell of the hair. This does not seem to be the case but instead the wall surrounding the entire cell is very thin. These hairs are simple trichomes, that is they are rather cells than organs. Unlike the tentacles of the sundew, in no case do the spiral bundles enter their tissue. I am inclined to believe that these cellular hairs serve more than one purpose in the economy of the plant.

A study of the structure and physiology of the whole family shows that all the forms need a great deal of absorbing surface for there seems to be a lack of stomata. The tissue of the leaf is almost constantly gorged with a large supply of nourishment consisting, evidently, of absorbed nitrogenous matter, and

pitcher of *Hellamphora* through the genus *Sarracenia* to the remarkable trap pitcher of *Darlingtonia* with its attractive appendages, digestive fluid and sweet lure, Mr. James says: "Scarcely any of the steps showing the progress are needed to complete the line of development. It can be traced directly from *Hellamphora* to *Darlingtonia*, and it is only necessary to have an ancestral form from which to start to have a complete pedigree. It seems probable that the water-lily family and the pitcher-plant family had a single ancestor in common. This ancestor was aquatic, or least an inhabitant of swampy places. It had small, probably peltate, perhaps reniform leaves, and these had hollow petioles. The inner space was lined with hairs as are now the inner surfaces of the stems of *Nymphaea* and its allies; it had a four or five parted flower, with many stamens and a broad stigma. From such an ancestor came two or three branches. One of these developed into plants having an aquatic habit, large leaves and long petioles, and peduncles like those which are found at present in the water-lilies. The other branch diverged to form plants living in boggy or swampy grounds, with pitcher-like leaves whose insectivorous proclivities were developed later on."

Mr. James suggests that these proclivities were developed by a true process of natural selection. The more or less saucer-like peltate leaves may possibly have held some water in which insects were drowned. This fluid, by standing causing the decay of the blade at the insertion of the petiole, found its way into the hollow petiole and finally by absorption of the nitrogenous matter the plants gained nourishment that could be used in its growth. This adaptation being of use to the plant might lead, in the next generation, to leaves better fitted for taking food in this manner. This in course of time would give rise to a generation of petioles peculiarly adapted to catching water and insects by being pitcher-like in form. The blade no longer needed for absorption would become a mere rudiment and then would follow the further process of perfecting traced by Mr. James in *Sarracenaceae*.

needs a great extent of surface exposed to the air for the purpose of absorption in carrying on the functions of assimilation and metastasis. In support of this there is considerable evidence, the most important of which is the fact that many of these hairs, especially those on the hood, contain chlorophyl. From a study of marked leaves through the whole season I am led to believe that some of the hairs are absorbed as the leaf grows old. This would indicate that as the function of the leaf are lessened the extent of absorbing surface is reduced.

When the leaf has apparently nearly stopped absorbing the moisture from the tube it may still be an active insect trap. At this time an especially strong odor is given off from the decaying mass of insects. It would seem that the insects caught now could be of no use except as a fertilizer, when by the decay of the leaves, all this mass of decomposing nitrogeneous matter is deposited around the roots of the plant. The decaying material, moreover, seems to hasten the decay of the leaf, as its vitality is lessened by the advancing season.

It is noticeable that there are many insects around the leaves just at twilight or when the sky is overcast with heavy clouds. Remains of nocturnal insects are also very common in the mascerating mass. This seems to indicate that flies and other insects seek the hollow leaves in which to retreat during the hours when they are naturally at rest. It is a fact that insects seek retreats of this kind.

True to the habits of the spiders to seek those places for their homes that flies frequent, there is one that makes its home at the top of the leaves spinning its web so that it nearly covers the whole opening. In each case that I have observed it is the same species but whether it always seeks the pitchers, I cannot state.

An insect lighting upon the leaf starts immediately to walk toward the inside. It seldom stops till the smooth place is reached where sooner or later it loses its foot-hold and falls. In some cases they try to fly upward from the bottom of the pitchers. In but one case have I seen an insect escape in this manner. This, a beetle, obtained its freedom by flying from one side of the tube to the other till the opening was reached.

A slight secretion has been observed by many near the opening of the pitcher. This seemingly has but little power to attract insects, though at times it is quite copious.

Mr. Joseph Jackson says,* "While collecting a few specimens of *S. purpurea*, L., I was surprised on drawing aside the petals to look at the stamens to see the whole cavity formed by the petals and the peltate expansion of the style filled with flies as large as the common house fly, all busy as could be eating the pollen, of which scarcely a grain could be seen. I counted fourteen flies in one flower. They were in no hurry to vacate the premises. There was a shower coming up at the time, but they were evidently there for food. Nearly every plant examined was filled in the same way."

Mr. J. F. James suggests† that perhaps "there is something in the pollen, or in some secretion of the flower which has the effect of stupefying or intoxicating the insect and that then they might easily be shaken from the flower, by the wind, into the open mouths of the rosette of leaves below."

My observations differ somewhat as to the usefulness of these insect visits to the flowers. There are two or three species of Diptera found in the manner described. They are evidently attracted to the flower by some property of the

*Bot. Gazette Vol. vi. No. 7.

†Amer. Nat. Vol. xvii, p. 284.

pollen or a secretion of some other part of the flower, but it would seem mainly for the purpose of aiding in fertilization for a lense reveals the fact that pollen is quite freely scattered over their backs. Moreover these plants flower during the latter part of May and first of June, while insects are caught during the months of May, June, July and August. Though without question some of the flies from the flowers do eventually find their way into the pitchers underneath, yet these species are not nearly so common in the decomposing mass as some other species. Some time was spent in taking notes as to the effects of this food upon the flies but without any results showing stupefaction.

The great question is: What purpose do the decaying remains in the bottom of the tube serve in the economy of the plant? In order to decide this question it will be necessary to know the chemical nature of the fluid found in the pitchers. Several chemical analyses were made under as widely different conditions as a limited region of country would allow. As a result of the examination of over 800 leaves I find that none contained any fluid before they had opened. These were collected from several localities. After opening there is no fluid till after the first rain except in a few cases when there has been a heavy dew.

The following table is the result of a series of twenty-five chemical analyses, selected from one hundred the total number made, and shows approximately the composition of the fluid before it contained any insects. The sediment is the result of evaporation:

Number.	Condition of the Soil.	Time in days since leaf opened.*	Time in days since rain had fallen.	Color of Fluid.	Dried Residue from Evaporation†		Reaction.	INORGANIC SUBSTANCES.	REMARKS.
					Organic.	Inorganic.			
1 Swamp	5	5	1	Clear...	3...	2....	Slightly acid	Ammonium, †Potassium, Carbonic Acid.....	
2 Swamp	8	4	4	Slightly Yellow..	9...	3....	Acid....	Ammonium, Lime, Potassium, Carbonic Acid.....	Under trees in edge of swamp.
3 Swamp	15	3	3	Yellow..	11...	4....	Acid....	Ammonium, Potassium, Sodium, Hydrochloric, Sulphuric and Carbonic Acids.	Under trees in edge of swamp.
4 Dry	20	18	18	Clear...	14...	5....	Acid....	Ammonium, Potassium, Lime, Sodium, Magnesium, Carbonic, Hydrochloric, and Sulphuric Acids.	At edge of woods in soil containing much lime.
5 Moist	6	2	2	Clear...	6...	3....	Acid....	Ammonium, Lime, Potassium, Hydrochloric and Carbonic Acids.	Not far from the last.
6 Wet	10	4	4	Tinged..	8...	3....	Acid....	Ammonium, Potassium, Sodium, Sulphuric, Hydrochloric and Carbonic Acids.	
7 Wet	12	8	8	Tinged..	10...	4....	Acid....	Ammonium, Potassium, Lime, Aluminium, Sulphuric and Carbonic Acids.	Near dusty road and under trees.
8 Swamp	15	14	14	Tinged.	20...	5....	Acid....	Ammonium, Potassium, Lime, Aluminium, Iron, Sulphuric and Carbonic Acids.	In neighborhood of several iron springs, near a road and under trees.
9 Swamp	11	5	5	Yellow..	7...	3....	Acid....	Ammonium, Lime, Potassium, Hydrochloric and Carbonic Acids.	In deep grass.
10 Swamp	7	4	4	Clear...	4...	1....	Acid....	Ammonium, Lime, Potassium, Hydrochloric, and Carbonic Acids.	In deep grass.
11 Swamp	7	4	4	Clear...	5...	1....	Nearly neutral.	Ammonium, Lime, Potassium, Sodium, Hydrochloric, and Carbonic Acids.	Same plant as last.
12 Swamp	14	6	6	Dirty...	13...	4....	Slightly acid	Ammonium, Lime, Potassium, Sodium, Aluminium, Carbonic, Hydrochloric and Sulphuric Acids.	In grass near woods and dusty road.
13 Swamp	9	5	5	Dirty...	7...	2....	Acid....	Ammonium, Lime, Potassium, Sodium, Iron, Aluminium, Sulphuric and Carbonic Acids.	In grass near woods and dusty road.
14 Swamp	10	6	6	Quite Clear...	4...	1....	Nearly neutral.	Ammonium, Potassium, Lime, Sodium, Hydrochloric and Carbonic Acids.	In open swamp near road.
15 Swamp	5	2	2	Quite...	2...	1....	Nearly neutral.	Ammonium, Potassium, Lime, Sodium, Hydrochloric and Carbonic Acids.	Open swamp.
16 Wet...	8	4	4	Yellow..	6...	3....	Slightly acid	Ammonium, Potassium, Lime, Sodium, Magnesium, Carbonic and Hydrochloric Acids.	Under grass.
17 Swamp	3	1	1	Clear...	2...	2....	Slightly acid	Ammonium, Potassium, Carbonic Acids.	Open swamp.
18 Dry...	8	5	5	Yellow..	4...	4....	Slightly acid	Aluminium, Iron, Potassium, Sodium, Ammonium, Silica, Sulphuric, Hydrochloric and Carbonic Acids.	Side of dusty road and in the shade.

19 Dry...	2	1	Clear	4....	2....	Nearly neutral	Ammonium, Aluminium, Potassium, Sulphuric, Hydrochloric and Carbonic Acids.	Side of dusty road and in the shade.
20 Moist	11	5	Yellow	5....	3....	Slightly acid	Ammonium, Potassium, Lime, Iron, Hydrochloric and Carbonic Acids.	In open swamp near iron springs.
21 Moist	13	5	Yellow	7....	3....	Slightly acid	Ammonium, Potassium, Lime, Hydrochloric and Carbonic Acids.	Under trees.
22 Wet	3	1	Clear	2....	2....	Slightly acid	Ammonium, Lime, Carbonic Acid.	Open swamp.
23 Swamp	5	2	Clear	4....	2....	Slightly acid	Ammonium, Lime, Potassium, Sodium, Hydrochloric and Carbonic Acids.	Open swamp.
24 Swamp	7	2	Clear	6....	2....	Slightly acid	Ammonium, Lime, Potassium, Sodium, Hydrochloric and Carbonic Acids.	Open swamp.
25 Swamp	8	3	Clear	5....	1....	Slightly acid	Ammonium, Lime, Potassium, Sodium, Hydrochloric and Carbonic Acids.	Open swamp.

*This has reference to the time since the leaf was in such a condition that rain could easily enter it.

†Number of parts in 1000.

‡It is probable that in each case when ammonium is reported, nitric acid was combined with it (N H 4, N O 3) but there being but a trace it could not readily be found without much concentration.

§The organic residue when examined with a microscope revealed the fact that it consisted, to a great extent, of pollen, various other vegetable structures, Infusoria, algae and the like.

The following tables represent analyses made each month to test the condition of the liquid as the season advanced. The ten enumerated in each table were selected from one hundred analyses made from leaves picked the last day of the month. In each set the two extremes are given and the intermediate ones illustrated well the mean numbers of the complete series of one hundred. The amount of residue is expressed in parts per 1000:

MAY.

Number.	Condition of the soil.	Time in dy's since rain had fallen.	Color of Fluid.	Dried residue from evap rat'n		Reaction.	INORGANIC SUBSTANCES.	REMARKS.
				Organic.	Inorganic.			
1	Swamp	15	Yellow	60....	4.....		Ammonium Potassium Lime, Sodium, Magnesium, Carbonic and Hydrochloric Acids.	In grass and protected.
2	Quite dry	23	Wine..	100....	8.....		Ammonium, Potassium, Sodium, Aluminium, Iron, Sulphuric, Carbonic and Hydrochloric Acids.	Very near dusty road.
3	Moist..	5	Dirty..	108....	5.....		Same as No. 1.	
4	Swamp	7	Dirty..	110....	4.....		Same as No. 1.	Near edge of swamp but away from dust of roads.
5	Edg. of Swamp	5	Wine..	130....	6.....	Acid.	Ammonium, Potassium, Lime, Sodium, Magnesium, Iron Hydrochloric and Carbonic Acids.	Near sandy hill-side.
6	Swamp	3	Yellow	68....	3.....		Ammonium, Sodium, Potassium, Lime, Hydrochloric and Carbonic Acids.	Protected by deep grass.
7	Swamp	1	Dark..	82....	2.....		Same as No. 6.	
8	Edg. of swamp	6	Dark..	110....	4.....		Ammonium, Potassium Lime, Magnesium, Aluminium Sulphuric, Hydrochloric, Carbonic Acids.	Near dry hill-side.
9	Dry...	6	Dirty..	105....	7.....		Same as No. 2.	Barren hill-side, clay soil.
10	Moist..	11	Wine..	115....	4.....		Same as No. 6.	Near dry, grassy hill-side and nearly under a willow bush.

JUNE.

Number.	Condition of the soil.	Time in dry's since rain had fallen.	Color of Fluid.	Dried residue from evap'rat'n		Reaction.	INORGANIC SUBSTANCES.	REMARKS.
				Organic.	Inorganic.			
1	Swamp	5	Dirty..	120...	7....		Ammonium Potassium, Lime, Sodium Magnesium.	Near road.
2	Edg. of Swamp	7	Dirty..	132...	9....		Aluminium, Sulph'ric, Hydroch'ric, Carbonic Acids.	Near road and large iron springs.
3	Moist.	2	Wine..	162...	10....		Same as No. 1, with Iron.	Near iron springs.
4	Dry....	3	Dirty..	150...	9....		Same as No. 2.	Near dusty road and sandy hill-side.
5	Dry....	1	Dirty..	142...	6....		Same as No. 3, with Silica.	Same.
6	Moist..	4	Dirty..	139...	13....	Acid.	Same as No. 4.	Same.
7	Swamp	6	Dirty..	157...	8....		Same as No. 5.	Near dusty road.
8	Swamp	3	Dirty..	173...	6....		Same as No. 2.	Near road and under trees.
9	Swamp	6	Dirty..	170...	5....		Same as No. 1.	In swampy place made by iron springs.
10	Swamp	4	Dirty..	147...	6....		Same as No. 2.	
							Same as No. 1.	

JULY.

Number.	Condition of the soil.	Time in d ^y s since rain had fallen.	Color of fluid.	Dr'd residu from evap- oration.		Reaction.	INORGANIC SUBSTANCES.	REMARKS.
				Organic.	Inorganic.			
1	Swamp	3		137	6		Ammonium, Potassium, Sodium, Lime, Magnesium, Hydrochloric and Carbonic Acids.	Remote from road but near barren spot.
2	Swamp	5		173	8		Same as No. 1, with Iron,	Similar place, but in swamp formed by iron springs.
3	Edg of swamp	11		195	12		Ammonium Potassium, Sodium, Lime, Magnesium Iron, Silica, Alu'm, Hyd' chloride, Sulph'ic, Carb'ic acids	Very near dusty road and sandy hill-side.
4	Swamp	15		200	7		Same as No. 3, without Iron.	
5	Dry ...	11		195	11	Acid.	Same as No. 3.	Same as No 3,
6	Swamp	15		203	6		Same as No. 1 with Silica.	In deep swamp, but where the sand could be blown in from a barren spot.
7	Edg. of swamp	15	DIRTY.	207	9		Same as No. 2 with Silica.	Similar position to that of No. 6.
8	Swamp	9		187	6		Same as No. 7.	
9	Swamp	8		196	7		Same as No. 3, without Silica.	Near road but in very swampy place.
10	Swamp	9		205	9		Same as No. 3.	In very swampy place, but near very dusty clay road bed and under branches from tree.

AUGUST.

Number.	Condition of the soil.	Time in days since rain had fallen.	Color of fluid.	Dried residue from evaporation		Reaction.	INORGANIC SUBSTANCES.	REMARKS.
				Organic.	Inorganic.			
1	Dry....	10		164	18		Ammonium, Potassium, Sodium, Lime, Aluminium, Iron, Silica, Carbonic, Sulphuric, Hydrochloric Acids. Same as No. 1.	Near road and near field of sandy soil. Large proportion of silica. Prevailing winds toward the plant from the field.
2	Dry....	5		200	14			A similar location. A large p. c. of silica.
3	Wet...	10		225	10		Same as No. 1.	A similar location but near edge of woods.
4	Wet....	15		205	8		Same as No. 1 without Silica, Aluminium or Sulphuric Acid.	Deep swamp.
5	Swamp	20		237	13	Acid.	Same as No. 1 without Silica.	Near road and under tall grass and weeds.
6	Dry....	20	DIRTY.	260	16		Same as No. 1.	In a damp but not very swampy place surrounded by barren sand-hills. Large proportion of silica.
7	Edg. of swamp	15		257	9		Same as No. 1 without Aluminium, Silica or Sulphuric Acid.	In deep swamp.
8	Moist.	5		245	12		Same as No. 1 without Silica.	Not near road but under trees.
9	Moist.	5		198	10		Same as No. 8.	In a tamarack swamp and under grass which held much dust.
10	Swamp	10		242	9		Same as No. 8.	

The oldest leaves to be found were in each case selected and it is thought that in all cases they were the growth of the season up to date. In preparation the leaf was cut open and the contents removed to a crucible, but in no case was the mass used unless of such a consistency that it would flow easily. The reaction was acid in each case but the degree of acidity increased each month and was very marked through July and August. To just what acid, if any particular one, the reaction was due in the liquid of the earlier pitchers is not certain, but in the two last months both Malic and Citric acids appeared, the former in greater abundance.

The analysis of the ash and the residue of the filtered and evaporated fluid was qualitative. The object being simply to see if there was any relation existing between the inorganic matter contained in the fluid and the surrounding soil, etc., it was not minute. In each case, where it was possible, the soil near by at all liable to get into the pitcher was analyzed. However, not all the inorganic salts could be accounted for as from the soil. Whenever it was evident that the inorganic matter was similar to the soil near the plant it is indicated in the tables under the head "remarks" by giving the character of the surrounding soil.

It seems highly probable that the first lot of insects merely decay after maceration in the water first collected in the pitchers and that this mass acts not only as a stimulant to further decay but also to render the liquid more capable of absorbing certain organic principles from the leaf, such as Malic acid, which aid in the preparation of the abundant supply of food for absorption by the leaf. Thus the first mass might be called a digestive excitant. There being no glands, the process of exciting the leaf to the secretion of an acid would be quite slow.

That this is the case, I feel assured by the fact that absorption evidently takes place much more rapidly during the last days of June and the months of July and August. It is then that much nutriment is needed and the cells are filled with matter. The large tubular cells in the structure of the lower part of the pitcher walls and in fact those extended downward into the root are at this time charged with matter, while earlier they are comparatively empty, though much nitrogenous matter has been in the leaves for several weeks.

By a set of experiments it was easily shown that the ammonia contained in the liquid, either having its source in the rain water brought to the plant, in the results of the decomposing remains of the insects, or in the absorption from the atmosphere was readily and quite rapidly absorbed by the leaf.

In these experiments it was assumed that but little would be absorbed by the liquid from the air, during the season of experiment, especially if it was a dry time. Such a time was therefore selected and the leaves so turned and propped that no rain could fall into them. The leaves marked were those that contained but few insect remains. Two in each case were examined from each plant. Great care was used that both should have the same age, amount of liquid and nearly the same amount of remains and especially that they should have as near the same size as possible.

One leaf was marked and treated as above while the fluid of the other was immediately tested for organic ammonia and the amount estimated. At the end of a week the marked leaves were picked, quickly examined and the fluid analyzed for organic ammonia. The fluid showed a decided decrease in each case, from the amount found in the one used in comparison. Though these analyses were perhaps quite far from sure in every detail yet the average difference on

comparison, viz: sixty parts in one hundred, would indicate quite rapid absorption, for such an amount could not possibly be removed in any other way.

Associated with the remains of insects in these pitchers and apparently nearly always able to overcome the obstacles to escape, are a few other insects.

The first of these a moth *Xanthoptera semicrocea*, Gneu. which feeds upon the tissue of the leaves themselves, is not so common in the leaf of the side-saddle flower as in the more southern species.

There is another moth besides this which is more common. Though I have not been able to study it to any extent, yet from a casual observation I feel convinced that it is not the same species as the above though the larvæ of both are very much alike. It is possible that it may be a new variety.

The egg is lain within the tube, generally about the middle of the leaf, and fastened to the smooth surface by a web so that seemingly the egg might not only be secure but that also the larvæ might have a secure scaffolding upon which to stand as soon as hatched when it immediately covers the smooth surface with the same kind of web and is thus able to go wherever it wills. It is often the habit of this insect to close the mouth of the pitcher in the southern forms. In a few cases I found threads stretched across the opening of the hood but it is impossible to close the lids of the northern pitcher plant. "As the larvæ increases in size it frets the leaf within feeding on the parenchyma and leaving only the epidermis." Occasionally these larvæ are found dead in the bottom of the pitcher. They had apparently fallen into the liquid and drowned.

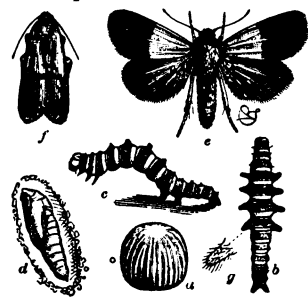
Another very common insect, even more common than the moth, is a fly, *Sarco-huga sarracenise*, Riley. A dozen or more living larvæ are dropped into the tube by the fly where they feed upon the decaying mass of insect remains.

As a rule but one larva matures, the others having been devoured by it.

The larva undergoes its metamorphosis in the ground at the base of the leaf. Its transformation is completed in about a week.

Dr. C. V. Riley, U. S. Entomologist, has kindly furnished me with very full descriptions and cuts of the moth, *X semicrocea*, Guen. and the fly *S. sarracenise* Riley.

These, with his permission, I append in full * for there are but few printed descriptions.



XANTHOPTERA SEMICROCEA—a, egg, enlarge; the natural size indicated at side; b, c, larva, back and side views; d, chrysalis; e, moth, normal form, with wings expanded; f, pale variety, with wings closed; g, enlarged tubercle of larva.

XANTHOPTERA SEMICROCEA Guen. Egg—Globular, slightly flattened at top and bottom; 0.02 inch in diameter. Color, when mature, grayish, with about 35 ribs of a paler color, some of them anastomosing and all becoming fainter toward the crown, which is smooth.

Larva—Average length 0.8 inch. Thickest in the middle of the body and having but three pairs of prolegs. Color deep crimson, or lake-red, the joints being deeply separated, and their borders, especially posteriorly, being white and strongly contrasting with the red. On each of joints 4, 5, 6 and 7 is a pair of more or less confluent, velvety-black, dorsal patches, and a subdorsal, fleshy tubercle, the foremost a little the longest, the others gradually diminishing in length. The other joints are each ornamented with about a dozen small, dark, conical tubercles, transversely arranged on 2 and 3, from a trapezoid to a square on 8, 9, 10 and 11, and on 12 in an opposite position to those on 9; on the cervical shield there are two rows and on the anal plate they are all brought close together. The red parts are more or less thickly beset with short, fuzzy, dark hairs, which are especially dense on the velvety patches and large tubercles mentioned. Venter from joint 8 to anus pale. Head yellowish-white with a deep brown transverse band around the mouth and the forehead, and an irregular spot of the same color on the top and on the front of each lobe. Thoracic legs dark brown; prolegs dusky.

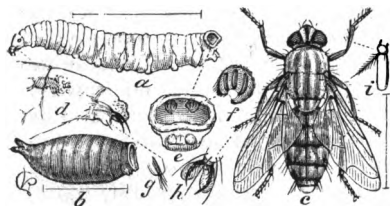
*Descriptions and Natural History of two Insects which brave the dangers of *Sarracenia variolaris*.—Trans. St. Louis Acad. of Science. By C. V. Riley, Ph. D.

The newly hatched larva is pale, with the dark bands noticeable principally on joints 4-7, the head uniformly pale-brown, and the tubercles scarcely noticeable and surmounted by one or more stiff hairs. In the second stage the tubercles become more prominent, but those on joints 4-7 are not relatively so much larger than the others. In the third stage the characters of the mature larva are assumed, except that the colors do not contrast so greatly, the short hairs are not so dense and the head is often unicolored.

Chrysalis—Uncharacteristic; varying from yellowish-brown to mahogany-brown in color; the head produced into a slight cone in front between the eyes, and the tip of the abdomen armed, in perfect specimens, with two straight converging thorns, and several smaller curled hooks.

Imago—Average expanse 0.8 inch *. Colors, glossy straw-yellow and black. Primaries with the basal half straw-yellow, varying from pale chrome to ochre; the terminal half brown-black with a gray and violet reflection; the two colors sharply separated across the wing at about a right angle from costa. Secondaries same as terminal half of primaries, but usually somewhat paler, especially toward base. Under surface uniformly purplish-gray, inclining to yellow basally, and with a somewhat darker median shade usually discernible on primaries. Head black,† with palpi beneath and antennae yellow. Thorax of the same two colors, sharply separated across the shoulders. Legs yellowish, the tarsi with minute spines, the spurs often with a spinous tip. Abdomen yellowish at base, otherwise concolorous with secondaries.

The species is very variable, the dividing line of the two colors, on primaries, being usually across the middle, but in some specimens much nearer the base of the wing. A striking variety (two specimens) is of a uniform straw-yellow, with the faintest dusky shade across the middle and subterminal portions of primaries; while several have the dark parts more or less suffused with yellow.



SARCOPHAGA SARRACENIÆ—a. larva; b. pupa; c. fly, the hair lines showing average natural lengths; d. enlarged head and first joint of larva, showing curved hooks, lower lip (g), and prothoracic spiracle; e. end of body of same, showing stigmata (f) and prolegs and vent; h. tarsal claws of fly with projecting pads; i. antenna of same. All enlarged, never more than 8), which in their turn ramify into lobules. Anal stigmatic cavity quite deep; the fleshy prominences on the carina surrounding it, sub-obsolete; the stigmata but slightly excavated below, the border brown, enclosing three brown openings, the lower ends of which reach to a circular clear space in the corneous and pale rufous peritreme. Anal prolegs quite small, with the longitudinal anal slit between, and a corneous plate in front of them.

Puparium—0.25-0.50 inch long; neither smooth nor highly polished, and varying from yellowish-brown to deep brown-black in color. Insections more or less distinctly traceable. Head and prothoracic joint retracted; the prothoracic spiracles, protruding and forming two small ears, about as long as joint 2; the mass of lobules hardened and rufous. Joints 2 and 3 constricted and flattened; 4 suddenly bulging. End of body squarely docked by spiracular cavity, the rim of which forms quite a ridge.

Imago—Length of body 0.23-0.56 inch. Head pale golden-yellow, especially when viewed from above, with a dark brown or bronze sheen, especially below; eyes ferruginous, in life; duller and bronze-colored in death; stripe between the eyes and all appendages jet-black, though showing, in fresh specimens, shades of brown or yellowish-brown, especially at inner base of antennae and on maxillipalps. Thorax pale ash-gray, with three prominent, dark, longitudinal dorsal vittae, and two which are shorter, on each side; the two intervening pale dorsal spaces showing also a narrow darker line along their middle; wings slightly fuliginous; tegulae sordid white; legs black, with the front thighs grayish beneath; cushions large and pale yellowish. Abdomen of the same gray—inclining, in some specimens, to pale golden-yellow, especially behind—checkered with black, the pattern varying with each change of light, but 3 longitudinal lines tolerably distinct from above, the side ones approaching or joining the medial one on the anterior part of each joint, and the whole looking checkered as the light falls on the sides; anus always, and frequently the hind margin of preceding or 4th abdominal joint, pale reddish-brown, the color deepening and becoming less noticeable in the dead specimen; the globular and highly polished male genital organ of a brighter and deeper reddish-brown.

*The writer finds the extremes of his measurements 0.6 and 1 inch.

†The writer has observed some specimens with brown heads.

REMARKS.—Though there is such great variation in size—depending, no doubt, on the amount of nourishment obtainable by the larva—there is not much in coloration. The species agrees tolerably well with the description of *CARNARIA* except in having a red anus, and should perhaps be considered only a variety of this last.

The larva differs from Packard's description of that of *CARNARIA* in the character of the prothoracic spiracle, in lacking the 12 blunt spines around the anal spiracular region, and in having the clear space in the peritreme of the anal spiracles, by which it seems to agree more with his description of *Calliphora*.

I also find a fly frequenting the pitchers and living upon the remains at the base of the leaf that agrees with the description of *Sarcophaga carnaria* L., or the flesh-fly.

My attention has often been called to the fact that *Musca Cæsar*, L., the blue-bottle fly, is found in the leaves of the Side-saddle flower as well as in some other forms of pitcher plants. (See page 409, Packard's Guide.)

I have often seen specimens of *Musca domestica*, L., the housefly, near the pitchers, but have never seen them inside except when dead. Neither have I been able to raise them from any of the larvæ. It is said, however, that they are known to live in the insect remains.

In answer to the question, "How do these insects succeed in escaping from the pitchers and have apparently perfect freedom in them," Dr. Riley suggests that in the case of the flies it is probably due to the large foot-pads and elongated claws that perhaps reach through the pubescens of the leaf and fasten to the cellular tissue beyond. Their great strength seems also to aid them in escaping by means of a continued buzzing and gradual movement upward. The only fly that seems to escape readily is the *Sarcophaga*.

The moth has the tarsi covered with long spines which are usually tipped with "a corneous point." The larvæ are perfectly safe in their web-like scaffolding.

Some time was spent in studying all these insects to see if they had any part in aiding the plant in fertilization. None of the insects living in the tube seem to ever frequent the flower. They are either there to feed upon the tissue of the leaf itself or are attracted by the odor of the decomposing mass to feed upon it.

As living insects prey upon the leaf and macerating mass so birds often frequent these leaves to feed upon the living insects. One is often surprised to see the number of ragged holes in the sides of, especially, old leaves. Some of these holes are made by insects in which case shreds of the epidermis still remain.

In several leaves that I knew had been opened by birds I did not find a single living insect. They seem to especially enjoy the fat larvæ of the *Sarcophaga* fly. It is a well known fact that birds when they obtain a taste of a new food that is especially enjoyable to them seemingly cannot be satisfied till there is no longer a supply. Perhaps this will explain the fact that in some localities the leaves will all be more or less torn while in others the leaves as a whole are without holes.

Though I have not been able to make any extended observation concerning the depredations of birds on the leaves, I have sufficient evidence to show that, in those years when the larvæ of the *Sarcophaga* fly are especially common, the birds prey to a great extent upon them.



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Assistant Director of the Geological Survey of Canada.

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BY DR. GEORGE M. DAWSON, D. S., F. G. S., F. R. S. CAN., ASSOCIATE
R. S. M., AND ASSISTANT DIRECTOR OF THE
GEOLOGICAL SURVEY OF CANADA.

(READ BEFORE THE CHICAGO ACADEMY OF SCIENCES JUNE 9, 1885, BY H. A. JOHNSON, M. D., F. R. M. S.)

In a paper read before the Academy in January, 1884, and printed in the bulletins of the Academy (vol. i, No. 4), H. A. Johnson, M. D., and B. W. Thomas, F. R. M. S., gave the results of an investigation by them of microscopic organisms in the boulder clay of Chicago and vicinity. This paper refers principally to certain remarkable bodies first found by these gentlemen in 1865-66-67, in specimens of the clay through which the lake tunnel, which supplies the city of Chicago with water from Lake Michigan, was being constructed. On the completion of the tunnel large numbers of the same bodies were observed in the filtrate from the city water supply, and which were subsequently proved to be identical with organisms described in 1871 by Sir J. W. Dawson from the Devonian shales of Kettle Point, Lake Huron. They have since been observed in the Devonian rocks of a number of widely separated localities, and are now believed by Sir J. W. Dawson to be macrospores of rhizocarps.* In accordance with this view the generic name of *Protosalvinia* is proposed by Dawson in the paper above referred to instead of *Sporangites*, which term is, however, still used in this paper. Properly speaking, this term would apply to the *Sporangia* containing these macrospores, and which are absent in the specimens in question. Mr. Thomas, in a note to the paper first quoted, refers to the additional discovery in boulder-clay from Minnesota, sent to him by Prof. N. H. Winchell, of several species of *Foraminifera*, evidently derived from the Cretaceous rocks of that region. Since

*Proc. A. A. A. S., 1883, and Can. "Record of Science," vol. i. See also paper by Mr. J. M. Clarke, American Journal of Science, vol. xxix, p. 284.

this announcement Mr. Thomas has mounted for the microscope and examined many samples of boulder-clays from various places, and has favored me from time to time with a number of his preparations. He has also kindly prepared and mounted specimens of several boulder-clays and allied materials collected in Manitoba and the Saskatchewan region. At his request the notes made by me on these last and on a few of those first mentioned are here offered. This paper must, however, be understood to be merely of a preliminary and general character, being based on the examination of less than one hundred microscopic preparations. It may, it is hoped, be supplemented later by a more detailed report, including the discussion of a larger suite of specimens, from a greater number of localities.

The microscopical investigation of these boulder-clays has resulted in the discovery of many objects which, while evidently of organic origin, are very difficult to name or classify, and require comparison with a wide range of bodies and reference to many works for that purpose. Mr. Thomas has also found that even in the case of those clays with which he is most familiar, each new lot of preparations mounted is almost sure to show forms not before observed, and that the field is an ever-widening one.

It is now, therefore, proposed merely to denote the classes of objects so far observed in the various boulder-clays, and when possible the genera to which the organisms belong, without attempting to catalogue them specifically. Neither is it here intended to enter into any further discussion as to the nature of the Macrospores occurring in some of the clays.

It should also be stated that most of the objects on the many slips examined, have been indicated by maltwood markings by Mr. Thomas, a circumstance greatly reducing the amount of labor involved in going over the material.*

Boulder-clays of Chicago and vicinity.

The preparations examined representing the boulder-clay of Chicago and vicinity are as follows: From Chicago lake tunnel, 86 feet down, 5 slides; North Chicago boulder-clay, 60 feet down, 11; North Chicago clay, 64 feet down, 2; North Chicago, 65 feet down, 10; corner of Washington and Clark streets, eight feet down, 1; or 29 in all. These are so similar in their general characters and the class of objects which they present that they may be considered together.

The inorganic material in these clays, as represented by the above preparations, consists largely of quartz sand, in which few well-rounded grains appear, most being sub-angular and many quite angular and unworn. With these is a notable proportion of bottle-green particles of hornblende,

*It should be explained that the material referred to in the succeeding notes is that part of the boulder-clay which is composed of particles of medium size, from which the very fine matter has, as a rule, been separated by decantation. This again has been sized by repeated decantations at intervals of one, two or three minutes. Mr. Thomas states that the greater number of examples of a given form are frequently thus obtained in material of a certain grade of fineness.

with a few of mica and feldspar. Nearly one-half of the entire material is, however, composed of flattened and rounded grains of fine shale, which have a dark brown color and granular texture by transmitted light. One or two of the quartz grains show included crystals, and many hold fluid or gas cavities. The bodies of organic origin most commonly met with are referable to *Sporangites* (*Protosalvinia*) *Huronensis*, Dawson, of the Devonian shales. These are extremely abundant, and the shale particles already described are doubtless derived from the disintegration of the same beds. They are in some instances very well preserved, but are also present in all stages of decay, and in many cases hold a quantity of granular, shaly, or clayey matter in their interiors. Besides these a specimen occurs in the material from the lake tunnel of entirely different character. It is a partly flattened sphere of 0.2 m. m. in diameter, with radiating and concentric structure, brownish color, and very small central cavity, or nucleus. This is similar to some of the bodies from the Devonian rocks described as macrospores by Mr. Clarke in his paper above referred to. Two more bodies of the same class appear in other preparations, but are more nearly transparent, and evidently in a different state of preservation. To one of them a small fragment of the matrix attaches and serves to show that both of these may have come from a lime-stone bed."

Next in abundance to the *Sporangites* is a class of bodies the true nature of which is very doubtful. Of these at least twelve large fragments were noted in the preparations under discussion, with many smaller and less characteristic pieces. They may be described as spines or spicules, generally cylindrical, but sometimes trough-shaped or triangular in cross-section, averaging about .05 m. m. in diameter, and of pale yellowish brown color. Their structure is very finely granular, and the outer surface more or less roughened, as though from erosion. They are in some cases distinctly tubular, with a small central cavity; others have a thick medullary portion, which is poorly defined, but differs somewhat in texture from the exterior. Some of the fragments terminate in acute points, others have a slightly swollen, rounded end, and one was observed to be doubly terminated and nearly spindle shaped. They appear to be calcareous, but whether this is their original condition, or the result of mineralization, is uncertain. They can scarcely be chitinous, being much paler in color than other specimens of this character met with in some of the preparations. So many organisms may have produced spines or spicules resembling these bodies that it is not yet possible to assign them definitely. They do not appear to be sponge spicules, but as their color and texture is not unlike that of the next class of objects, they may possibly be partly mineralized chitinous setæ of Annelids, derived from some of the subjacent rocks. Their diversity in shape is such that they must either represent several species or belong to different parts of some organism in connection with which several types of appendage of this character were developed. (Fig. 1.)

Among the most interesting bodies found in these clays are certain comblike objects which are regarded as Annelid jaws. Of these, four, all fragmentary, have been observed. They were at first supposed to be teeth from the lingual ribbon of some mollusk, but on more careful examination were found to be unlike the teeth of any mollusk of which figures can be found, and, moreover, to correspond almost exactly in form with some of the Annelid jaws described by Mr. G. J. Hinde from the Silurian and Devonian rocks of Canada.† One of the specimens shows a series of long and curved prongs. (Fig. 2.) Three others apparently belong to a single type, in which a nearly flat plate is armed along one edge with a series of small, close denticles arranged somewhat obliquely to the line of attachment. (Fig. 3.) Like the bodies last described they are of a pale straw color, differing in this respect from Mr. Hinde's specimens, which are said to be shining and black; but this difference may arise from the mode of preservation. They exhibit no reaction with polarized light, and are smooth and not distinctly granular. The ends of the prongs or denticles are worn and roughened as though by use.



Fig. 1 (x130)



Fig. 2 (x130)



Fig. 3 (x130)

Organisms from the Chicago boulder-clays.

Other bodies occurring in these preparations in smaller numbers need not be referred to in detail. Two broken specimens evidently represent Ostracoda. They show no well marked sculpture, but a minutely granular structure. The most perfect is .31 m. m. in length. A third specimen, somewhat larger, and also broken, is either a small Sphærium or a very young specimen of some larger shell. All three have adhering to them brownish shaly particles, which appear to indicate their origin, though it must be remarked that the shell substance is very well preserved and fresh-looking. Still another specimen is a broken piece of the edge of a large calcareous shell or carapace, beautifully marked, and possibly that of an ostracod of another species. The remaining objects observed are mere fragments, quite indeterminate in character. Among these are small pieces of a delicate ribbed shell, the ribs being square in cross-section; a rather large chitinous fragment, striated externally, but without any other apparent structure, and one or more pieces of straight tubular siliceous spicules probably belonging to some sponge.

The probable sources of the organic bodies in these clays is discussed subsequently in connection with those from other places.

† Quarterly Journal of the Geological Society, 1879, p. 370.

BOULDER-CLAYS FROM BLOOMINGTON, ILL., 107 FEET DOWN.

This clay immediately underlies an interglacial deposit of soil and peaty matter with remains of wood, etc.* Of this clay five preparations only have been examined. The coarse material is here chiefly quartz sand, of which by far the larger proportion is sub-angular. There are also a few grains of amethystine quartz, showing sharp conchoidal fracture. Several quartz grains show inclusions, one of very small hexagonal red crystals, probably hematite. Hornblende grains are moderately abundant, but shaly fragments, such as those which make up a large proportion of the material from the Chicago clays, are almost or altogether wanting. A few Macrospores exactly like those previously noticed occur, together with one or two specimens of the pale brownish granular spines, or setæ, found in the Chicago clays. A small, flat, curved, finely-ribbed body in one of the slips resembles part of the edge of a carapace. While therefore not altogether wanting in this clay, organic traces appear to be very scantily represented.

BOULDER-CLAYS FROM MEEKER COUNTY, MINN.

This material is derived from a well shaft sunk in Meeker County, at a depth of about twenty-two feet, and was transmitted to Mr. Thomas by Prof. N. H. Winchell, State geologist of Minnesota. Mr. Thomas has made a large series of preparations from it, a number of which I have had the opportunity of inspecting.

As the Foraminifera contained in these preparations are being named and catalogued by Messrs. A. Woodward and B. W. Thomas, the remarks here given are confined principally to the general character and contents of the clay, with the object of comparing it with those from other localities.

The coarser material from this clay, as it appears in the preparations, is chiefly quartz sand, which is generally sub-angular, though with some well-rounded grains. Hornblende and mica appear in about the usual proportions, and two quartz grains with very beautiful inclusions were noticed, one being probably either hornblende or rutile, the other possibly apatite. A large proportion of the material, however, consists of rounded grains of shale, of gray or greenish-gray color by transmitted light, and not nearly so dark as the shale mixed with the Chicago clays. In specimens boiled in nitric acid, the shaly fragments have become reddish from the oxidation of their iron.

Of organic bodies present in these specimens of Minnesota clay, the *Foraminifera* are most prominent and important. They are evidently derived from the Cretaceous strata, and resemble those found in the western development of these rocks, both specifically and in mode of preservation. *Rotalidæ* and *Textularidæ* are most abundant, though specimens of *Globigerina* and other genera also occur. Next in abundance to the *Foramin-*

*This stratum of soil is about 6 feet thick, and underlies 101 feet of boulder-clay. I do not know the thickness of the clay deposit below the inter-glacial soil, but both the upper and lower clay deposits carry an abundance of glacial-marked boulders.—B. W. T.

ifera are remains of *Radiolaria*. Some difficulty was experienced in deciding the true nature of fragments of these bodies at first met with, but the subsequent discovery of numerous and often well-preserved specimens, and the observation by Mr. Thomas that they resist boiling in nitric acid, now leave no doubt as to their character. Several genera and quite a number of species are represented, and it will eventually be possible to determine many of these forms specifically. Most appear to belong to the Polysphæridæ and Cystidæ of Haeckel's classification. The constant occurrence of these bodies with the Cretaceous Foraminifera in the Minnesota preparations and in those from other places, with their absence from materials not equally characterized by the Foraminifera, leaves little room to doubt the common origin of both. Among miscellaneous objects from the Minnesota clay may be mentioned a few fragments apparently identical with the minutely granular spines or setæ described as occurring in the Chicago clays; also two broken portions of stout siliceous spicules, about .026 m. m. in diameter, one smooth, the other tuberculated; both tubular, and probably belonging to some sponge. Lastly, a single specimen of a very curious body, of straggling and irregular form, composed of numerous expansions differing in shape and size and pretty uniformly pitted and connected by narrow, smooth necks. As this is in one of the preparations which has been treated with acid, it must be siliceous. I can only suggest that it may be the siliceous cast of some foraminifer like *Aschemonella catenata* of Norman the arenaceous test of which has been composed of calcareous particles which have left pitted impressions on the cast. Against this is the fact of its small size, it being about .2 m. m. only in greatest diameter.

BOULDER-CLAY FROM CRETE, SALINE CO., NEB.

This material, Mr. Thomas informs me, was obtained from a single small excavation. It was forwarded to Mr. Thomas by Prof. G. D. Swezey, and is described by him in a letter to Mr. Thomas as a blue clay underlying the loess. The inorganic matter in the preparations made from it consists largely of fine angular and sub angular quartz grains, with a small proportion of green hornblende and much shale or earthy limestone in little particles which differ in color and texture. It is extremely rich in organic forms, chiefly Cretaceous Foraminifera, so much so that it seems probable that it is largely composed of the debris of the Niobrara division of that formation, and that a complete study of its contents would practically include that of all the forms occurring in the chalky limestone of that stage. The present notice of it must therefore be considered as of the most general and preliminary character only. Of this material a suite of thirty-one preparations has been examined, and in an enumeration of about one hundred of the best preserved forms, nearly fifty per cent belong to the *Textularidæ*, the remainder being made up in nearly equal proportions of *Globigerinidæ*, *Rotalidæ*, miscellaneous *Foraminifera* of other families, and *Radiolarians*,

resembling, and in some cases identical with, the Minnesota species. Fragments of calcareous prisms from the shell of *Inoceramus* and in the finer matter specimens of *Coccoliths* and *Rhabdoliths* also occur; all resembling in every respect similar bodies found in the Niobrara rocks of Nebraska and Manitoba.*

Many of the Foraminifera are completely filled with calcite, while others are still partially hollow, and yet others are filled partly with calcite and partly with black carbonaceous or bituminous matter. Of objects of an unusual character two may be specially referred to. A rod-like body about .2 m. m. in length, narrowed near the middle, though broken at one end, and marked by numerous pits in linear series. This may be a small spine from some *Echinoderm*. Also a hollow conical tooth or spine, evidently that of a fish, also broken, but still .25 m. m. in length.

BOULDER-CLAY FROM A WELL AT ROSENFELD, MANITOBA.

This material, sent to me under the name of "Hard-Pan," was obtained at a depth of 135 feet, in a well bored by the Canadian Pacific Railroad Company at Rosenfeld, Manitoba. It formed, mixed with gravel and boulders, a layer of eighteen feet in thickness, below the post-glacial alluvial deposits of the Red River Valley and resting on a Silurian shale. As the well was bored with an ordinary percussion drill, it is possible that some matter from the alluvial deposits above referred to may have been mixed with the specimen of "hard-pan," but so far as examined these alluvial deposits do not hold any organic forms. Numerous small particles of steel from the edge of the drill occur in the six preparations representing this clay.

The inorganic constituents are coarse in texture; quartz grains, of which nearly one-half are perfectly rounded, as usual predominating. Bottle-green hornblende is moderately abundant as are also fragments of feldspar and limestone, but shaly materials are almost altogether wanting. Bodies of organic origin are rather scarce, Foraminifera, however, being most common, and a *Textularia* of the type of *T. globulosa* is characteristic. A few *Rotalidæ* are also present, with broken chambers of other Foraminifera. The examination of a greater quantity of the material would doubtless lead to the discovery of all the ordinary Cretaceous types.

BOULDER-CLAY FROM THE SOUTH SASKATCHEWAN RIVER TEN MILES EAST OF THE MOUTH OF THE SWIFT CURRENT.

This and the two following localities in the Canadian northwest territory are represented by specimens collected by Mr. R. G. McConnell. The three localities lie between the 106th and 108th meridians, and represent a portion of the great drift-covered area of the northern plains. The material from this place is, as usual, largely siliceous, but there is a larger proportion

*See a paper by the writer in the *Canadian Naturalist*, 1874.

than common of coarse, thoroughly-rounded quartz grains. Hornblende and other crystalline minerals from the Laurentian or Huronian are also present, and there is a notable quantity of amethystine quartz in angular fragments. Comminuted gray shale, very finely ground, is moderately abundant. Bodies of organic origin are not frequent. In pretty carefully examining a series of six preparations, about ten only were met with. These are *Textulariæ* and rotaline *Foraminifera*, with one very small *Globigerina* and a couple of *Radiolarians*; one very perfect, oval and .09 m. m. longest diameter. (*Haliomma*?) A fragment was also found of bony substance, showing haversian canals and probably portion of a ganoid scale. There is also in these preparations a number of rounded and flattened grains, nearly transparent, though in some cases with a more opaque central spot, and surface minutely and regularly roughened. These were eventually determined by comparison to be fragments of some pearly shell, probably that of *Unio*, a form quite abundantly represented in the Cretaceous and Laramie rocks of the region. The appearance of an opaque nucleus in some examples appears to result from the non-penetration of the mounting medium to the centre of the larger grains.

BOULDER-CLAY FROM TEN MILES NORTH OF THE SOUTH SASKATCHEWAN, EAST
OF MISSOURI COTEAU, TOWNSHIP 21, RANGE 10, WEST OF 3D PRINCIPAL
MERIDIAN.

The material in six preparations from this clay differs from the last described only in the much greater quantity of comminuted shaly matter of a reddish-brown tint. Bodies of organic origin are here again scarce. No *Foraminifera* were found. Two or three broken pieces of minute rod-like pitted objects, very doubtfully referred to small spines of some *Echinoderm*, and evidently identical in character with that previously described from Saline County, Neb., were detected. Those occurring here are about .015 m. m. in diameter. Another somewhat similar object is rather stouter and with a roughened surface without regular markings. A small broken piece of some chitinous test was also observed, but on the whole this material is very barren.

BOULDER-CLAY FROM THE SOUTH SASKATCHEWAN, FIFTEEN MILES ABOVE THE
ELBOW.

In the preparations from this clay—eighteen in number—the sandy material is much finer than in the two last. It is nearly half composed of shaly fragments of brown color, the quartz sand being also rather more angular than usual. It is richer in organic forms than either of the other specimens from the neighborhood of the South Saskatchewan. About half a dozen specimens of *Foraminifera* were recognized in the preparations, one being probably a small *Discorbina*, others *Textulariæ* and broken chambers of *Globigerina*. These are not so well preserved as in some of

the other clays, and in some cases the shell itself appears to have been removed, leaving only a rough cast in calcite. *Radiolarians* are here (so far as the examination of a small quantity of material can be accepted as conclusive) even more abundant than *Foraminifera*, spherical, oval and turbinate forms all being represented, and in some cases in such connection with fragments of the abundant shaly material as to leave no doubt as to their common origin with it. Small, partly rounded prisms from the shell of *Inoceramus* are also present, together with a few pieces of straight hollow siliceous spiculæ, one specimen of a minutely granular spine or seta, with a distinct medullary portion like some previously noticed, and .026 m. m. in diameter, and one of a portion of a body like that previously referred with doubt to an *Echinoderm* spine.

CONCLUSIONS.

In inquiring as to the derivation of the various organic bodies in the clays, it is necessary to consider the situation of each locality with reference to known areas of the older rocks, from the disintegration of which they may have come. The *Sporangites* so abundant in the Chicago clays have been definitely traced to the shales of the Devonian age, and have doubtless been brought to their present position from outcrops to the northward in the Michigan peninsula. It has already been stated that the bodies supposed to be Annelid jaws may probably have been derived from the same beds, or from others of the Devonian or Silurian rocks of this part of the country. With regard to the remaining bodies no definite statement can at present be ventured, though there is every reason to believe that they might very well have come from the same rocks.

In the clays from Bloomington, in the center of the State of Illinois, *Sporangites* are again the most characteristic bodies, though much less numerous in correspondence with the greater distance from the shale outcrops. A few other objects associated with these are not dissimilar to those in the Chicago clays.

Meeker County, from which the specimens of Minnesota boulder-clay were derived, is in the southern and central portion of the State, and is underlaid, according to Prof. N. H. Winchell by rocks of the Archæan period, overlain probably, at least in some places, by shales of the Cretaceous. As might be anticipated from the absence of Devonian rocks, both in this locality and the whole region to the north and northeast, *Sporangites* have not been observed in this clay. While the greater part at least of the organisms are evidently referable to the Cretaceous rocks, the locality lies to the northeast of the generally recognized edge of that formation. Prof. Winchell has, however, proved the existence of a number of outliers of Cretaceous beyond the main area occupied by these rocks, and it is probably from one of these, possibly not remote from the actual position of the clay, that the *Foraminifera* and *Radiolaria* have come.

The clay from Crete, Saline Co., Neb., is, as already observed, so rich in Cretaceous forms as to lead to the belief that it is largely composed of the debris of the chalky limestone of the Niobrara stage, and may rest upon or lie very near to the outcrop of these beds. I am not in a position to state whether the geology of the district bears out this conclusion. The map shows at least that Cretaceous rocks underlie this part of the State.

The material from Rosenfeld, Manitoba, shows a smaller number of forms, but these are equally characteristic of the Niobrara stage, the outcrop of which, though concealed by alluvial and other deposits, can not be many miles west of the position of the well, and also runs northward along the base of the Pembina escarpment, having been recognized at a point about fifty miles northwest of Rosenfeld on the Boyne River. ("Geology and Resources of the 49th Parallel," p. 78). As there is little probability of the existence of any Cretaceous rocks directly north or to the northeastward of this place, the occurrence of Cretaceous Foraminifera would tend to show that material derived from the northwest had been incorporated with the boulder-clay of this district.

The three localities near the South Saskatchewan may be treated of together, in so far as the origin of their organic constituents is concerned. The general movement of the material composing the glacial deposits of the northern plains in a southwesterly direction has already been demonstrated (see "Quarterly Journal of the Geological Society, 1875," p. 605; "Report of Progress of the Geological Survey of Canada, 1882-84," p. 139), and it would appear that the Cretaceous Foraminifera must also have been carried from the vicinity of the eastern Cretaceous outcrops at a great distance. It is true that the clays here rest on Cretaceous beds, but these are not as a rule calcareous, or such as to yield Foraminifera in the state of preservation of those found in these clays. The Niobrara limestones are not only unknown in the entire district from which the clays come, but their place appears to be taken in this region by the Belly river beds, which are arenaceous and argillaceous. Other organic fragments present in these clays may well have been derived from the Cretaceous or Laramie beds of the immediate neighborhood.

In reviewing the general bearings of the microscopical examination of these boulder-clays, representing as they do a few points only, scattered over a wide area in the central portion of the continent, it would be unwise to endeavor to draw any very definite or too general conclusions. The field appears to be a promising one for future inquiry, and the present paper can be regarded only as in the strictest sense, preliminary. It would appear, however, that of all the organic bodies met with none can be assigned with certainty to the glacial period or era of deposition of the boulder clay itself. The origin of most can be traced unequivocally to the older rocks, from which they have been derived, and incorporated with the boulder-clays. Of all the bodies enumerated the only ones which, on account of their pres-

ence in clays, holding otherwise different sets of forms, may possibly be of contemporaneous origin with them, are siliceous sponge (?) *spicules* and the peculiar spines or setæ several times referred to in the foregoing. To these may be possibly added the Ostracoda from the Chicago clay. While it is therefore probable that the examination of these organic fragments will serve to throw additional light on the direction of transport of material during the Glacial period—a point of particular value over the wide area of the plains, where the soft character of the rock precludes the test of direction of striation—it has so far failed to afford any certain information as to the actual conditions prevailing during that period. The negative evidence, reinforced by the fact that derived bodies have been perfectly preserved, so far as it goes, leads to a belief in the great scarcity of contemporary life. The occurrence of inter-glacial peats and the inclusion of wood and other vegetable matters in the boulder-clays of a number of widely separated localities in the West (see “Vegetable remains in Drift Deposits of the Northwest,” by Prof. N. H. Winchell, Proc. A. A. S., 1875; “Report of Progress of the Geological Survey of Canada, 1882–84,” p. 144) prove, however, that life was not constantly absent, and it may therefore reasonably be anticipated that further search will eventually lead to the definition in the clays of at least such contemporary organisms as may have been derived from these inter-glacial deposits, and possibly of others strictly contemporaneous with the boulder-clays themselves. The well-rounded character of a considerable proportion of the sand in some of the specimens points to prolonged water action, but there is no means of deciding to what extent in each case previously rounded sand grains have been included in the clays. The comparatively unworn appearance of the majority of the Foraminifera and other delicate objects, on the contrary, indicates rather tranquil conditions of deposit, and negatives the occurrence in the case of these materials of any extensive differential motion in the substance of the clay itself, which would infallibly have destroyed these very fragile organisms. Mr. Hugh Miller, in a carefully worked out paper on “Boulder Glaciation” (“Royal Physical Society, Edinburgh,” vol. viii, p. 157), describes a fluxion structure in the Scottish till or boulder-clay, and notes instances of sand grains so shaped and striated as to represent microscopic glaciated boulders which he conceives to have been “slidden along and glaciated in these places in the clay.” No confirmation of this observation is afforded by these clays. Though many grains of an elongated shape show what might at first be taken for such striation, it is apparent in almost every case on close examination that the lines are really structural and that the shape of the grains is here, as in ordinary sands, governed to a great extent by the pre-existing cleavage or jointage planes of the material of which they are composed.

The microscopical examination of these boulder-clays bears out the conclusion arrived at from their macroscopic characters that, while largely composed of far-traveled material, they invariably contain a considerable proportion of material of local, or proximately local, origin.

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SOME POINTS

ON THE

MICRO-CHEMISTRY OF FATS.

4 plates

By JOHN H. LONG, Sc. D.

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Before the beginning of this century investigations concerning fats and oils were confined almost entirely to the preparation of a few soaps, plasters and burning fluids. The action of alkalies on fats was explained by assuming that the two classes of bodies united without excluding any thing. Even the fact that a metallic compound, as lead acetate, could precipitate an alkaline soap, seemed to suggest little. Scheele, in 1779, separated glycerine from olive oil, and later, from other fats; but, like Priestley, wedded to the old Phlogiston theory, he failed to perceive the great importance of his discovery.

The first satisfactory explanation of the nature of fatty bodies was furnished by the work of Chevreul, commenced in 1811, and by the analyses of others, who, taking up the investigations suggested by this chemist, soon showed the general correctness of his views. Fats were thus proven to be ethers of organic acids, in which glycerine was usually the basic part, and saponification, accordingly, consisted in replacing this glycerine by a metallic oxide. The investigations of Wurtz on the composition of glycerine, and of Berthelot and Heintz on the synthesis of fats, bring this part of the subject down to the present time.

The constitution of these bodies being settled, it now remained to study their various reactions, and improve methods of separation and identification.

We may regard the following formulas as established:

		Molecular weight.
Glycerine	$(C_3 H_5) O_3 H_3$	92
Stearic Acid	$(C_{18} H_{35} O_2) H$	284
Palmitic Acid	$(C_{16} H_{31} O_2) H$	256
Oleic Acid	$(C_{18} H_{33} O_2) H$	282
Butyric Acid	$(C_4 H_7 O_2) H$	88
Caproic Acid	$(C_6 H_{11} O_2) H$	116
Tri-stearin	$C_3 H_5 (C_{18} H_{35} O_2)_3$	890
Tri-palmitin	$C_3 H_5 (C_{16} H_{31} O_2)_3$	806
Tri-olein	$C_3 H_5 (C_{18} H_{33} O_2)_3$	884
Tri-butylin	$C_3 H_5 (C_4 H_7 O_2)_3$	302
Tri-caproin	$C_3 H_5 (C_6 H_{11} O_2)_3$	386

With very few exceptions, all natural fats consist of mixtures of the last five bodies, and numerous processes have been suggested for separating the constituent parts.

A rough separation can be effected by partial crystallization from some menstruum, or by melting and cooling gradually, in which case the more solid fats separate first.

Fats containing volatile acids can be treated in this way: They are first decomposed by saponification, and treated with dilute sulphuric acid to throw out the free fatty acids. The volatile ones, as butyric, can now be distilled off, or washed out by hot water, in which they are soluble. Methods of analyzing butter are based on these principles. The separation of stearic, palmitic and oleic acids from each other is a problem of very great difficulty, and can be best accomplished in this way, as given by Oudemans (*Fres. Zeit.* 1867, p. 454.) After saponification and precipitation of the fatty acids, an alcoholic solution of the latter is prepared, from which lead acetate throws down the lead salts. These are dried and treated with ether, in which oleate of lead is soluble, while the stearate and palmitate are not. The acids can be separated from the lead readily and weighed, or further treated. The method is not very accurate, as the lead oleate is not easily soluble in cold ether, while, if the latter is warmed, small amounts of the other salts pass into solution.

Palmitic and stearic acids are separated from each other by the process of Heintz. The mixture is dissolved in hot alcohol, and treated with a hot alcoholic solution of magnesium acetate, in such proportion that only about one-seventh of the amount necessary for total precipitation is added. Under these circumstances nearly pure magnesium stearate separates.

From the residue a second and third precipitates are made, and so on. The final ones consist chiefly of magnesium palmitate.

By decomposing all the fractions and repeating the process, it is possible to obtain the one acid in several portions practically free from the other. By uniting and weighing the fractions the desired result is obtained. This process was proposed by Heintz in 1851 (*J. B.*, 1851, p. 639). and modified by himself and others later.

As an analytical method it is seldom followed, but for obtaining the pure acids for experimental purposes it answers very well, and was employed by Heintz in preparing the materials for his work on the synthesis of fatty bodies.

The determination of the amount of stearic and palmitic acids in a mixture is usually accomplished by this indirect method.

The molecular weight of stearic acid being 284, and that of palmitic being 256, one C.c. of a $\frac{1}{10}$ normal sodium hydrate solution would neutralize 28.4 Mg. of the former and 25.6 Mg. of the latter. By a simple calculation from the weight of the mixed acids taken, and the C.c. of alkali used, the proportions of the two acids may be deduced. The method is fairly accurate when due precautions are taken. The acids must be dissolved in pure alcohol, or alcohol of known acidity, and a proper indicator, as phenol-phtalein, must be used.

Account must also be taken of the fact that the free acids hold some water, about 3.25 per cent. These equations may be employed in calculating the amounts of acid in such a mixture:

$$\begin{aligned}\text{Let } x &= \text{wt. of stearic acid,} \\ y &= \text{wt. of palmitic acid,} \\ a &= \text{wt. of mixture,} \\ b &= \text{wt. of Na O H used.}\end{aligned}$$

$$\begin{aligned}\text{Then } x + y &= a \\ \frac{10}{284} x + \frac{10}{256} y &= b\end{aligned}$$

$$\text{From which } x = 10.143 a - 64.914 b$$

A determination of the fusing point of a mixture of the two acids may give some idea of the amounts of each present, but the uncertainties of the method are sufficiently indicated by this table:

Stearic.	Mixture of Palmitic.	Melts.	Solidifies.	Texture.
100	0	69.2	69.2	Crystalline scales.
80	20	65.3	60.3	Fine needles.
60	40	60.3	56.5	Non-crystalline.
40	60	56.3	54.3	Large plates.
30	70	55.1	54.0	Non-crystalline.
20	80	57.5	53.8	Indistinct needles.
0	100	62.0	62.0	Scales.

To be of value these tests must be made with very great accuracy, and both melting and solidifying points must be found.

In practice, the processes mentioned prove of little value in the identification of a majority of the natural fats. In some cases so-called color tests are of use here. These depend on the tints produced by certain reagents when mixed with different fatty bodies, and among the reagents may be mentioned sulphuric acid, nitric acid, zinc chloride, sodium hydrate, hydro-chloric acid and sugar, and several others. At first sight,

one may be pleased by the simplicity of these tests, but on trying a large number uncertainty creeps in, when it is found that various mixtures may be made to yield the colors supposed to be characteristic of some one substance.

It has been known for a long time that nearly all fatty bodies will crystallize under appropriate conditions, and in forms which are, to a certain degree, characteristic.

The study of a few of these fatty crystals is the main object of this sketch. The literature of the subject is meager and very unsatisfactory. Several authors since Chevreul, Berthelot and Heintz, have referred in a general way to the crystalline forms assumed by natural and artificial fats when crystallizing from various solvents, but evidently, no very great importance was attached to these observations. Attempts were made to distinguish between butter and some of its substitutes by microscopic tests, it being claimed that pure butter was characterized by an absence of small crystals, while other fats, used to adulterate it, possess a multitude of these, especially visible when viewed by polarized light. Some ten years ago, Hassall, in his work on food adulterations, showed the fallacy of this, which fact, however, seems to have been lost sight of by later observers. In a French scientific paper I found, some years ago, reference to the crystallization of certain animal fats, with the statement that from this could be developed a means of identification. Unfortunately, I have lost my memoranda relating to this paper, and can not now recall where I saw it. I think it was published between ten and fifteen years ago, and it was among the first notices relating directly to identification.

In the last five years the subject has received more attention. The following pages embrace the results of my own experiments, commenced in the winter of '82-'83, and which are still in progress. In my investigations I have tried several methods of preparation for microscopic examination.

First Method. Small portions of the fats in question were pressed down to a thin layer between a cover glass and slide, and then examined by ordinary and polarized light, using powers from 75 to 250 diameters. In this way crystals already existing can be detected, but in most cases there is little characteristic about them. Below, under the discussion of butter, it will be seen what use can be made of them.

Second Method. Here a small fragment of the solid fat was melted on a slide, and allowed to cool slowly. In this manner crystals can be obtained, but solidification is usually too rapid to permit large and characteristic forms to appear. By softening the fat by addition of a little olive oil, somewhat more satisfactory results can be obtained, but in

neither case is a free and perfect crystallization possible, as in the following methods.

Third Method. This is the ordinary procedure of crystallization from solution. A small amount of fat was dissolved in ether, carbon bisulphide, chloroform or other menstruum in a beaker or watch-glass, and allowed to stand, until by spontaneous evaporation most of the liquid had passed off. After removing the mother liquor, the deposited crystals were examined on slides in the usual way.

In this way very perfect crystals can be made, but they are not as sharp as when made as follows.

Fourth Method. Here the fats were dissolved as before, and a drop or two transferred to a slide. In a short time, by spontaneous evaporation, a film makes its appearance on the surface of the drop, and at this stage a cover is carefully placed over it, and the slide is allowed to stand until complete crystallization takes place. This requires, in some cases, but an hour, while in others a day or more is necessary. Of all solvents I have found chloroform the most serviceable, and nearly all the crystals described below were made by its use.

I pass now to a discussion of the several fats.

BUTTER.

I have above referred to the opinion once held, that pure butter is composed of non-crystallized fats, and when viewed by polarized light exhibits no refraction phenomena. Hassall and others, as mentioned, have pointed out that on standing, butter soon loses this peculiarity. It has also been found that perfectly fresh butter, and even cream, may sometimes show crystalline forms.

I have been able to confirm these observations as regards butter, but have never found crystals in cream.

When butter is freed from water and salt by melting at a low temperature, and then dissolved in chloroform and crystallized by the fourth method, several forms are observed, the most usual of which are given in Figs. I, and II.*

Crystals like Fig. I, having a diameter of $\frac{1}{160}$ to $\frac{1}{100}$ inch, are very abundant. They consist of fine silky filaments radiating from a center, the field presenting a somewhat wavy appearance, well shown in the figure. Viewed by polarized light the bright crystal on a dark ground appears marked by a cross, as shown under tallow. Fig. II shows another interesting form. We have here a portion resembling Fig. I joined to, or extending into a plate-like bundle of needles similar to some mentioned below.

* The cuts were made from micro-photographs by the photo-engraving process, with two exceptions. The bees-wax plate and that by polarized light were made from drawings.

In some cases these needles lie so close together as to be undistinguishable from plates, with ordinary powers, and are similar to the common plates of lard or mutton tallow.

Fig. III bears a striking resemblance to Fig. I. The crystals represented here were obtained from pure stearin, by crystallizing it at a very low temperature. On allowing a drop of the chloroform solution, on a slide, to remain over night, the field was found, when examined in the morning, to be thickly covered with the forms here shown.

Nothing else could be seen, and these disappeared on the application of a slight degree of warmth. So delicate are they that I made several attempts to photograph them before succeeding, and then only after removing my instruments to a cold room. It is possible the butter crystals may have a similar composition. Other forms observed will be referred to below.

BUTTERINE.

Samples of butterine, as now found in the market, show a large number of forms when crystallized from chloroform solution. I have observed forms very closely resembling Figs. IV, VII, XV and XVI. We have here a complex body, and the proportions of the several fats used are, without doubt, of great influence on the manner of crystallization. I wish to reserve the subject of butterine crystals for a fuller discussion at a future time, and hence, will not enter into details here.

MUTTON TALLOW.

Mutton tallow and others to follow consist almost entirely of the glycerides of palmitic, stearic and oleic acids, that is of acids of large molecular weight, which are not readily volatile without decomposition. Butter fat differs from these substances in this, that it contains 8 to 10 per cent. of glycerides of volatile acids. There is necessarily a marked physical difference between butter and other fats, and we should expect corresponding differences to appear in the microscopic forms. Figs. IV, V, VI, VII, VIII and IX give the chief forms found in mutton fat. All of these crystals can be found on one slide, and frequently two or three in the same field. It is not easy to say which is the most characteristic or numerous. Nos. IV, V and VI are readily produced, and are, in a certain sense, primary forms. They are among the first which become clearly defined on the evaporation of the chloroform, and are very stable, remaining many months, perhaps years, in perfect shape. Nos. VII, VIII and IX are peculiar. Crystals separate from chloroform solutions of mutton fat very quickly, some forming within a few minutes, while others separate out after a longer time. Very soon a field is found which consists of well defined rhomboidal plates, Fig. VII, which differ from Fig. IV in this,

that they are shorter, and, as will be seen, less stable. If one watches them carefully, he will find them undergoing a change by splitting in the direction of their greatest lengths into bundles of needles. Soon these diverge from each other at the ends, giving the appearances well shown in Figs. VIII and IX. The divergence is often greater than here shown.

I have followed these changes very closely with the microscope, and in one instance made photographs of two fields to show this.

Fig. VIII is, in fact, an enlarged portion of the crystals of Fig. VII, and was taken four hours later. This change of rhomboidal plates like Fig. VII, to bunches of divergent needles, as shown in VIII and IX, is somewhat characteristic of mutton tallow. Growth and change of crystals can be observed in nearly all fats, but this peculiar change I have not noticed elsewhere.

BEEF TALLOW.

Very fine crystals can be obtained from this substance, but the variety is probably not as great as in the case of mutton fat. The more usual forms are represented in Figs. X, XI, XII and XIII. Very frequently I have observed crystals which differ from X only in this, that the needles terminate without crossing at the center. Figs. XI, XII and XIII are well represented. The last named is one of the commoner forms found in the fat of the dog. In Fig. XI the nucleus is not quite in the center, but I have found in tallow many crystals in which it is in the center, and when such are viewed by polarized light we obtain the effect well given in Fig. XIV, the cross being exactly similar to that referred to under butter. I have occasionally found in pure tallow masses of crystals similar to those of Fig. IV. These are more frequently found when the tallow is mixed with a small amount of fatty oil.

LARD.

Lard differs, qualitatively, very little from beef or mutton tallow, but quantitatively, it is characterized by a larger amount of olein. The microscopic forms are not numerous. Figs. XV and XVI show those most commonly seen. The rhomboidal plates of XV are usually sharply defined and transparent, as they are very thin. They resemble closely the plates found in mutton tallow. In Fig. XVI we have a combination of an imperfect plate with a plumose tuft, somewhat similar to a form found in butter, but not quite the same. Another form seems to consist of very small plates which have undergone a partial change by sending out spines as in some of the mutton tallow crystals. The spines are, however, very short and sharp. It is possible that Fig. XVI grew in a somewhat similar manner. A change, in some degree analogous to this, may be observed by crystallizing beeswax from chloroform. The plates which first form are equilateral rhomboids, but after a time these change in a very remark-

able manner. The points farthest apart become blunt, and send out little spicules. These grow by curving outward until the dumb-bell of Fig. XVII is reached. The first and intermediate forms are also shown in XVII, and the process of change can be readily followed by the microscope.

In mixtures of lard and tallow numerous plates resembling XV can be found, and, in general, everything found in each, provided proper proportions be taken. When equal parts of the two fats are mixed the crystals formed are frequently of the types shown in Figs. XVIII and XIX. Fig. XVIII is very characteristic, consisting of plates expanded at one end into tufts of curved needles. In Fig. XIX we have a number of over-lying plates, the ends of which have grown into tufts. By varying the proportions, very different results can be obtained. When the tallow is largely in excess a very common form is produced, shown in Fig. XX. This form polarizes as XIV. Needles form much more readily than plates.

HUMAN FAT.

In examining the fats above mentioned I took for solution portions representing the average composition of the whole substance. Melted human fat readily separates on cooling, into two layers, a liquid, and a semi-solid mass. For my tests I worked with the latter, which had the consistency of lard.

Two forms are readily found on microscopic examination, and beyond these not much more. These are well shown in Figs. XXI and XXII, of which those like XXI predominate. Sometimes the very fine needles radiate from the center in all directions, and without curvature.

DOG FAT.

The fat of the dog crystallizes from chloroform solution in fine wavy needles, radiating from a center. Fig. XXIII shows a very common appearance. Other forms are similar to fine crystals of butter shown in Fig. I, and to the tallow-lard mixture of Fig. XX. The cross by polarized light is perfectly exhibited.

CAT FAT.

Fig. XXIV shows a form of crystal readily obtained from solutions of cat fat. Other forms consist of imperfectly shaped plates observed in mutton and butter.

It will be observed that butter fat and the last three described have this in common. Their ordinary mode of crystallization is in exceedingly fine lines or needles radiating from a nucleus. The lines of lard, beef-tallow, or mutton-tallow, are not as fine or feathery as those just mentioned. Butter and the other fats resemble each other, even when very

fresh, in having a strong and characteristic odor, showing the presence of relatively large amounts of volatile substances. These volatile matters are doubtless glycerides of lighter acids, and the addition of a small amount of such substance makes a change in the appearance of the crystals, as I have found by adding a little artificially prepared glycerine butyrate to some mutton tallow.

OTHER FATS.

In his classic study of the composition of fats Berthelot prepared a number of them artificially, by heating mixtures of glycerine and the fatty acids. (*J. B.*, 1853, p. 451.)

By heating equal weights of glycerine and stearic acid in a sealed glass tube to a temperature of 200°C. for 26 hours, he obtained, after eliminating the uncombined acid and glycerine, mono-stearin. In like manner he prepared di-stearin and tri-stearin, and the glycerides of other acids.

Soon after this Heintz went through the same processes, obtaining like results. (*J. B.*, 1854, p. 447). According to the process proposed by Berthelot, I have prepared several of the fats, and studied their crystalline forms. The results have not been altogether satisfactory, or just what I anticipated. There are many difficulties in the way of purifying some of the products when prepared, but until this is done I think we cannot expect to reach a fair explanation of the many forms observed in these crystallizing bodies.

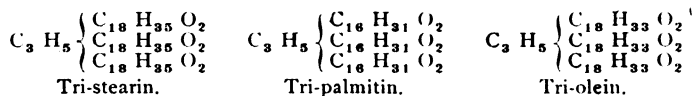
Several hypotheses may be presented to account for the numerous modes of crystalline aggregation observed in the photographs I have made, but it must be admitted that no one of them amounts to a satisfactory explanation. It is usually held that the ordinary phenomena of di- and tri-morphism, observed among mineral crystals, are brought about by variations of temperature at time of crystallization. It is also known that several simple substances of perfectly definite composition crystallize in different forms from different solvents.

Among the simpler fatty bodies I have noticed a remarkable variety of forms in samples of pure stearic acid, prepared by fractional precipitation, and in pure stearin.

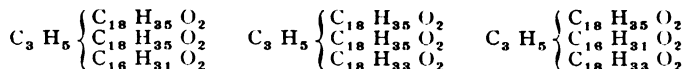
If we assume that these samples were not absolutely pure, which is of course probable, there comes up another hypothesis worthy of consideration. Williamson, in advancing his theory of etherification (*Chem. Soc. Quar. Jour.*, IV, 229), and Clausius in discussing certain phenomena of electrolysis (*Pogg.*, CI, 338), proposed an explanation of the nature of solutions, which has been of great assistance in the study of many reactions. They held that the component parts of a molecule in solution can not be considered as firmly linked to each other, but as continually moving about, exchanging places with corresponding parts of other molecules.

KCl and NaNO_3 in solution form some NaCl and KNO_3 , so that at any one time we may consider four substances present, instead of two. This hypothesis may be extended to molecules of greater complexity.

Referring to the formulas on page (74), we see that we have in most natural fats three groups:



In solutions, more could be formed from these, as:

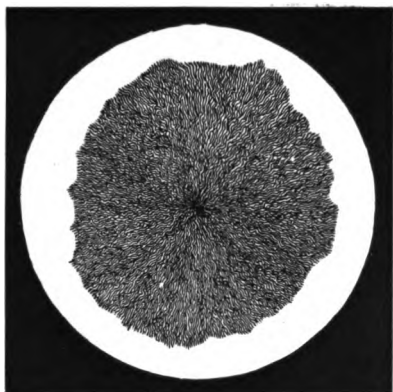


If we consider a fourth or a fifth fat present, as in the case of butter, a much greater number of combinations would be possible, and I think it probable that at the time of crystallization some of these secondary forms would separate out, just what ones, depending, of course, on conditions of temperature and concentration. At one instant the conditions may be right for the formation of one nucleus, and at the next for the formation of another.

While many combinations are possible, a few are more probable because of their stability; just as in the cases of isomers among alcohols and hydrocarbons.

I believe that by working at lower temperatures, I could have obtained an even greater variety of crystalline aggregates than indicated above, as was indeed suggested by my experience with stearin. These considerations lead me to think that the microscopic identification of mixtures of fats is a problem of much greater difficulty than might appear at first sight. I think ultimately a great deal may be accomplished in this direction, but until the various effects of temperature and percentage composition are understood; until they have been demonstrated by actual experiment, I think it unwise to lay very great stress on results obtained in this way.

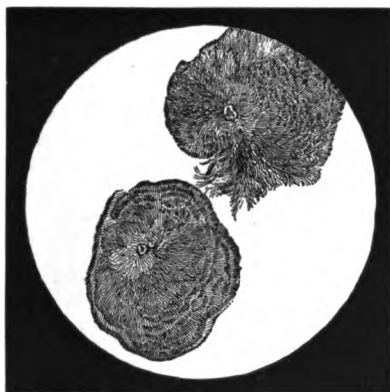
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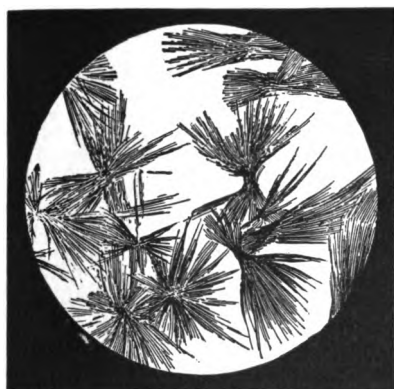
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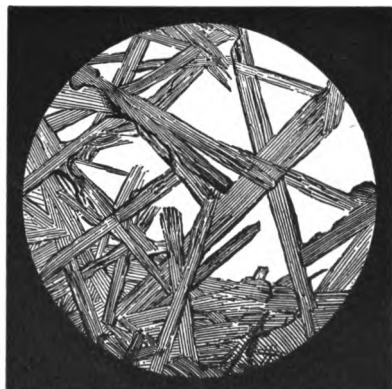
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V.



VI.



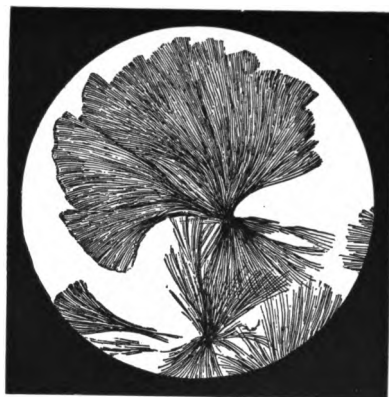
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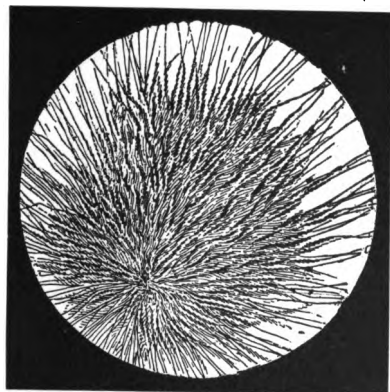
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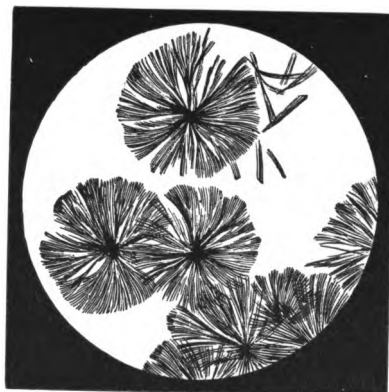
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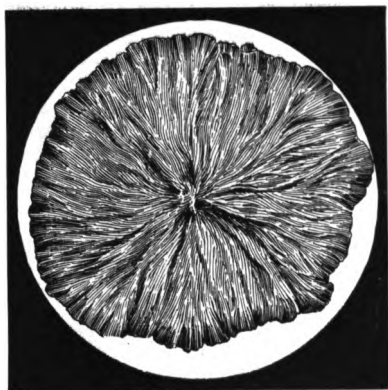
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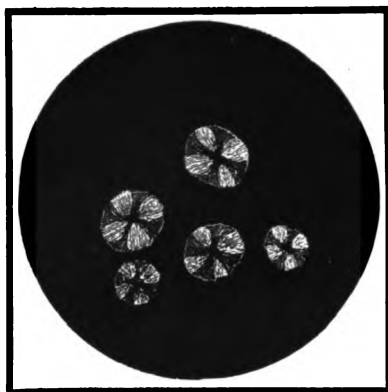
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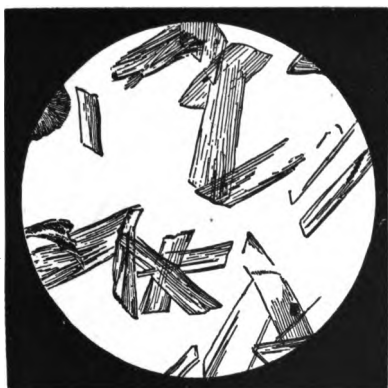
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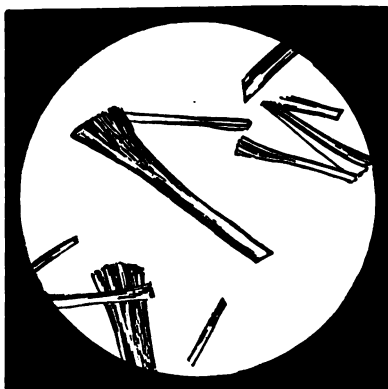
XV.



XVI.



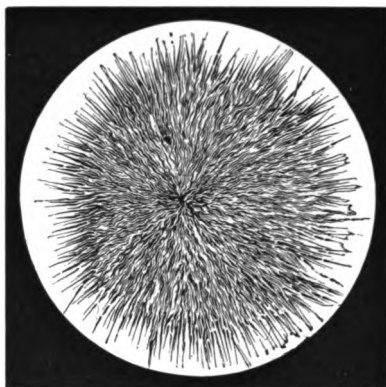
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XVIII.



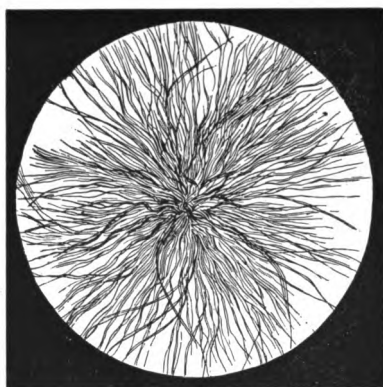
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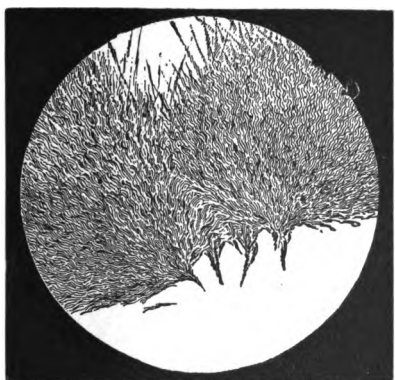
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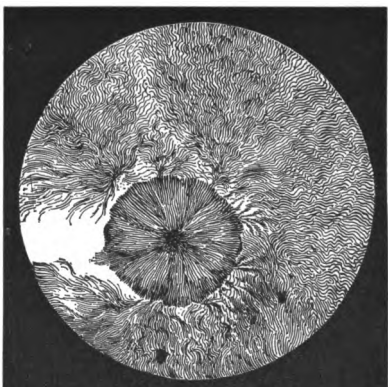
XXI.



XXII.



XXIII.



XXIV.

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CHICAGO ARTESIAN WELLS.

ON THEIR STRUCTURE AND SOURCES OF SUPPLY.

By LEANDER STONE, A. M.

READ BY THE AUTHOR BEFORE THE CHICAGO ACADEMY OF SCIENCES,
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THE ARTESIAN WELLS OF CHICAGO.

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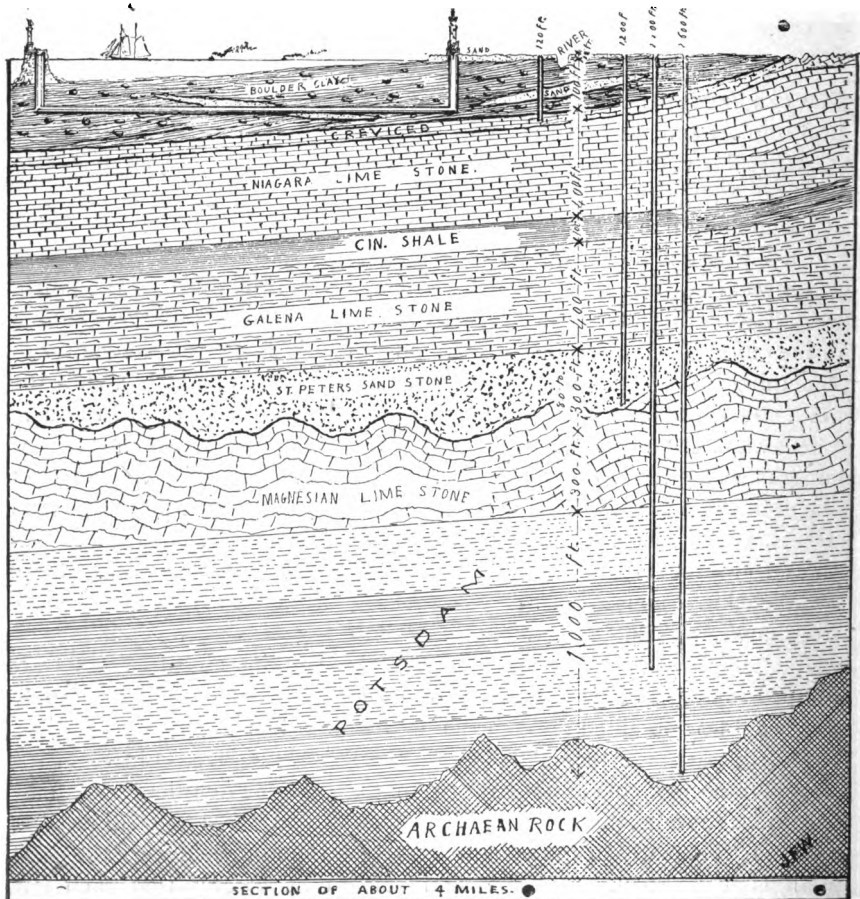
The water supply of Chicago is one of the most important subjects that can engage the attention of its citizens. The lake is the most natural source; but the fact that the greater part of the sewage flows into it, particularly at certain periods of the year, makes the subject of a pure water supply quite difficult.

Something like twenty years ago the first artesian well at the Union Stock Yards was bored, the depth being about 1,200 feet. The flow of water was free and large. A little earlier a well was sunk in the north-west part of the city called "*The Artesian Well*," because it was the first in the city. The object sought was oil, not water; but at the depth of something like 1,200 feet a good supply of water was obtained. Before the fire a considerable number of artesian wells had been made, all of which, I believe, overflowed and gave a very free supply. After the fire a new impetus was given to the business. Wells were bored in a number of places in the heart of the city—at the corner of State and Washington streets, at the Palmer House, at J. V. Farwell's wholesale house on Franklin and Monroe streets, at the Singer building and at other points. Every large packing house in the region of the Stock Yards has one or more artesian wells. There are nineteen in this region alone, yielding each day of ten hours 1,065,000 gallons. Nearly or quite all these wells are pumped to their full capacity, and so made to yield a much larger supply than would be obtained through the natural overflow.

At the parks are several wells—on the West Side, five; Lincoln park, two; South park, one. Nearly or quite all of the distilleries and malt houses have wells, and the total number in the city and immediate suburbs must be nearly or quite eighty. If the ratio of yield were the same in all as at the Stock Yards the total amount of water raised each day

would be about 4,500,000 gallons; but the ratio is much less and an estimate of 3,000,000 gallons each day would be much nearer the truth.

The rocky strata which underlie Chicago, it is well known, are substantially like those of eastern Wisconsin and dip to the east or south-east, rising to the surface at various points at a distance west of lake Michigan. They form the lowest group of distinctly fossiliferous deposits, and are commonly known as the silurian. From the products of the drill in excavating the shafts through these layers, as well as from the out-cropping, it is known that next below the boulder or drift clay lies the Niagara limestone, which is followed in order by the Cincinnati shales, the Galena and Trenton limestones, the St. Peter's sandstone, the lower magnesian limestone, the Potsdam sandstone and the Archaean or Crystalline rocks. The following is a general representation of the proportional thickness of each:



It will be seen that there are in Chicago four different classes of wells, according to the depth. First, there is a considerable number which go no further than just through the clay and into the superficial layers of the Niagara limestone. There are perhaps twenty of these wells, in all of which, with one exception, the water stands at a level not far from that of lake Michigan.

Second, There is a large number which reach down to 1,200 or 1,250 feet and end in or near the St. Peter's sandstone. Nearly all the wells sunk soon after the great fire, and for several years before, were put down to this level and yielded good supplies, which overflowed with various degrees of force and copiousness. It was soon discovered, however, that as the number of wells sunk to this depth increased the flow of those already made decreased, until some ceased to overflow altogether. The well at Central, now Garfield Park, at first rose to a height of forty feet, and yielded forty-three gallons per minute. The supply grew less as new wells were made, until the Park Commissioners tried an experiment to prove whether the supply was common to all the wells. At their request all the wells in the city, with one or two exceptions, were closed for several hours, when it was discovered that the water rose to a considerable greater height than usual in all the wells. This was regarded as conclusive evidence that they were fed by a common reservoir, and also that the water quite freely flowed from one to another. From the time that it became evident that the supply from the old wells would certainly be diminished by every new well, the well-makers turned their attention to ascertaining whether a lower stratum of water-bearing rock could not be found which would yield a supply unaffected by the upper.

New wells were put down to 2,000 and even 2,200 feet, when a supply was found equal or superior to that in the St. Peter's sandstone. This forms the third class of wells.

The fourth class is deeper, and in one case reaches the depth of 2,604 feet, or within thirty-six feet of half a mile. One general fact seems to be borne out by the analysis of the various wells, that the deeper the wells the greater the amount of solid mineral matter. The Lehman well, near the corner of Diversey avenue and N. Clark street, is said to be the deepest artesian well in the State, and the deepest flowing well in the United States. It is 2,604 feet and six inches in depth, and contains in each gallon of water over 322 grains of solid mineral matter, or more than one-half of one per cent. Two hundred gallons of water evaporated, would leave more than a gallon of solid sediment, much more than half of which would be common salt.

Most, or perhaps all, of the wells 1,200 feet deep contain too much lime to permit of the water being used in making steam. The well of Mr. Lehman doubtless extends nearly to the archæan rocks, as represented in

the diagram. I am indebted to the kindness of the Hon. Wm. Bross for procuring for me from the contractors, Gray Brothers, Milwaukee, carefully recorded sections of four wells along the lake shore north of the city. A comparison of the four, one of which is owned by Mr. Bross (the Winnetka well) will afford some interesting statistics. In order that they may be more readily considered I group them together :

	Lake Bluff.	Winnetka.	South Evanston.	Rogers Park.
Clay.....	207	184	74	72
Limestone.....	320	316	316	308
Shale.....	198	192	174	185
Limestone	216	247	228	238
St. Peter's sandstone.....	167	212	458	317
Red marl.....	32	45	12	...
Limestone.....	46	114	84	...
Potsdam sandstone.....	...	356	274	...
Total depth.....	1186	1666	1620	1120

The table is such that read from left to right the order is south and towards Chicago. The Lake Bluff well is something like thirty miles from that of Rogers Park. The Niagara limestone, the Cincinnati shale and Trenton limestone, it will be seen, are quite uniform in thickness. The St. Peter's sandstone shows a great thickening at Rogers' Park and South Evanston, while next below it is a peculiar bed called red marl, which seems to begin somewhere north of Lake Bluff, reaching its maximum depth at Winnetka and thins out at South Evanston, and between that and Rogers Park disappears. This red marl, lying next below the St. Peter's sandstone, is the equivalent of an easily broken unhomogeneous rock which is quite uniformly found in the Chicago well shafts. It seems to be neither sand nor lime, more or less fragmentary and easily crumbled. Mr. Stanford, ex-President of the West Park board, says that in sinking the Garfield Park well to a lower depth this rock was so easily broken down that a cavity of something like a barrel in size was formed before the drill began to perforate the more solid rock below.

In addition to the above classes of wells, it should be said that in the northwestern part of the city, in the vicinity of the old toll gate on Milwaukee avenue, there are several wells yielding a good supply of water at a depth of only about 800 feet. These are all within a half a mile of each other, and I have not learned of any others in the city. The vein appears to be local, and is not met with anywhere else.

The source of the water supply for the lower water-bearing rocks is easily accounted for, since all the lower strata rise to the surface at successive distances west and northwest of lake Michigan, and at altitudes which would give a pressure sufficient to force the water to and above the

surface of the highest bluffs on the coast. In Wisconsin wells have been bored at Sheboygan, Milwaukee, Racine and Kenosha, and the strata, which are water-bearing at a depth of many hundred feet on the coast, crop out in the interior—those at Sheboygan, at Green Lake; those at Milwaukee, at or near Beaver Dam; those at Racine, at Janesville, and those at Kenosha, at the Rock river. These inland points are each enough higher than the surface at the lake to cause an overflow at the lake shore; and artesian wells at points west from the shore grow less in depth as they are distant from the lake. The shallow wells at Oshkosh vary in depth, according to Prof. Chamberlin, and are from 15 to 100 feet.

The wells of Chicago, which pass through the blue clay and "hard pan" into the upper layer of the Niagara limestone, and stop there, have caused some debate as to the source of supply. In these wells, as a rule, the water rises to a point not far from the level of the lake, and thus the opinion has been formed that they are fed from the lake, which backs up through the crevices in the limestone. As the rock is exposed under the water of the lake at various points, such an opinion appears plausible. A careful consideration of the facts only will enable us to form a correct opinion.

The first of these wells was that of Mr. W. F. Bloom, which was made a short time before the great fire. It is situated at the corner of Thirty-fifth and Bloom streets. Mr. Bloom began to dig in the clay in the old-fashioned way, with pick and spade, for water. After he had gone forty feet he came upon the solid rock or hard pan. He then began to drill a shaft $1\frac{1}{2}$ inches in diameter. After passing through two feet of hard pan, two feet of shale and about three feet of limestone the drill dropped a few inches, and a copious supply of water was the result. The water passing up through this small aperture quickly filled the well, some five feet in diameter. Mr. Bloom made a persistent effort to pump the water out, using a common suction pump and a chain pump, and failed to make an impression on the volume of water. He filled the well up to within a few feet of the top with broken bricks and stone, and then made a curb about it. The water is sweet and pure and has never failed, although it has been freely used by the neighbors for many years. It has been supposed that the water stands at a level with the lake and rises and falls with the lake-level.

Some time later Mr. A. S. Piper sunk a similar well a short distance from Mr. Bloom's, at the corner of Ashland avenue and Twenty-seventh street. This well-shaft passes through fifty-six feet of clay and fourteen and one-half feet of rock. The diameter is three inches. A fire engine was employed for some time in a vain effort to exhaust it. It is used to supply a horse barn and about forty horses. The water is pure and good, but I have no analysis.

Mr. F. S. Swalley has constructed a large number of these wells with a bore of six inches through the clay and five inches in the rock. Messrs. Libby, McNeil & Libby, packers, have two wells near Sixteenth and State streets, within about eight feet of each other. The pumping of one does not seem to affect the supply of the other. The wells pass through about ten feet of sand, fifty-five of clay and hard pan, and end thirteen feet in the rock. The water is thoroughly impregnated with iron and sulphur, and cannot be used in steam boilers. The engineer reports that he has several times lighted the gas which rises through the water in the morning after the wells have remained unused through the night. The supply is about forty gallons a minute. There is another of these wells at Twenty-seventh street and the lake, owned by the U. S. Distilling Company. It passes through twenty-seven feet of sand, thirty feet of clay, ten feet of hard pan and thirteen feet of rock. The supply is very small, only about twelve gallons per minute.

Mr. Chas. Pope has one for his malt house at 488 North State street. It is about three hundred feet from lake Michigan, and the water is almost exactly like pure lake water. The Huck Malting Company, corner of Canalport avenue and Eighteenth street, has a well from which the water at one time flowed over the top at a level of about eight feet above the river. It is the only one of the shallow wells that overflows. The shaft passes through ten feet of alluvium, sixty feet of clay, five feet of boulders and hard pan and several feet into the rock. The well yields about forty-five gallons per minute.

Near the corner of Market and Erie streets, on the North Side, is another of these wells, which, after reaching the requisite depth in the rock, about fifteen feet, had to be pumped out completely several times before the water flowed into it freely. The pumping seems to have freed the well from clay which clogged the openings in the rock at the base of the bore.

The wells of the class constructed at Goose Island, on the north branch, are much impregnated with lime and sulphur, and the water cannot be used in steam boilers. One of the finest wells of this class is at Mr. Jennings' laundry, at 405 West Madison street. It passes through ninety feet of clay, six feet of hard pan and fourteen feet of rock—a gray limestone. The water is perfectly soft and pure—softer than lake water. It is used by the proprietor for washing purposes, for which it is much better adapted than the lake water, and the water is sought by many of the neighbors and used in preference to that from the hydrants for drinking and culinary purposes. I asked Mr. Artinstall, the city engineer, if he would not mark a bench at this well, giving the altitude above the city datum, and he very kindly deputized a surveyor to run a level to the well. The mark of the surveyor is 17.454 feet above the lake. This mark is

6.25 feet above the concrete floor where the tube of the well terminates. I was unable to measure the height of the water in the well owing to the fact that it is inaccessible by reason of the pumping machinery; but the foreman said the level of the water when the well was completed, stood about twelve feet from the surface, which would be less than a foot from the lake level. The Jennings well is a prize worth far more than it cost. It seems to have an unlimited supply of water. The deepest of the wells sunk by Mr. Swalley was near the crossing of Larrabee street and North avenue. Here was tried a suggestive experiment. Usually the drill is stopped after reaching from twelve to twenty feet within the Niagara limestone. In this well water was reached at twenty feet, but the flow was only moderate—about nineteen gallons—and to see if it could be increased the drill was sunk seventy feet further, but without augmenting in the least the flow. This experiment seems to prove that the water-bearing rock is superficial and does not exceed about twenty feet. This contractor has put down something over twenty of these wells. Some have failed to yield a sufficient supply to be of any utility—twelve gallons per minute being regarded as the practical minimum. In one case a sand pocket was found in the clay in a boring made near the intersection of Carroll avenue and Ada street, which was not exhausted except by vigorous steam pumping for eight to ten hours. Usually in passing through the clay water had to be supplied to the drill by pouring in at the top. The temperature in all these wells, winter and summer, ranges from 50 to 55 Fahrenheit.

The source of supply for these shallow wells is not altogether easy to settle. The fact that the water stands in them at or very near the level of the lake has given rise to a general belief that the rocks from which the water is derived afford communication by connecting fissures with the water of lake Michigan. It seems, however, that the levels of these wells are not uniform. One overflows at an elevation of eight feet above the lake and others vary more or less. Besides, the quality of the water differs through varying degrees. The water of the well at 405 Madison street is said to be purer and freer from lime than the lake water; while most are too much impregnated with lime or iron to be used for making steam. It is quite certain that the water is affected by the rock which is in close contiguity to the several wells. The diversity of the water seems to afford strong presumptive evidence that the supply is local and not broad and general.

There are various more or less wide areas within and near the city where the Niagara limestone comes to the surface, or so near it as to receive the rain which sinks into the crevices and cracks, which are more numerous in the top layers than in the deeper measures. At Archer avenue and Twenty-fourth street, at Eighteenth and Lincoln streets, in the northwestern portion of the city, and a little further west in Cicero, are

quite wide areas, where the rain falls upon the fissured rocks and sinks into it, and ultimately finds its way below the clay, where the drill of the well-borer meets it. At the quarry of Dolese & Sheppard, in Cicero, south of the Burlington & Quincy railroad, the miners' families get water from wells drilled in the limestone to a depth of thirty feet. Water to the amount of from twenty to thirty pails a day can be procured from these wells in all but the dryest times. The water percolates through the rock and into the wells, and, in this case, these wells are not more than twenty or thirty rods from the quarry. As an indication of the amount of water which these exposed rocks carry below the clay, it may be mentioned that on August 2d, when something over five inches of rain fell within twenty-four hours, the steam pump at the Eighteenth street quarry was operated all day Sunday, all of Sunday night and until Monday noon before the quarrymen could work. This engine has a cylinder of ten inches stroke and eight inches in diameter, with sixty strokes a minute. This would raise about 172,000 gallons in twenty-four hours. In a year there is a total rain fall in this country of about forty inches, which would give eight times as much water to carry off in the twelve months. The upheaval which throws up the rocks to the surface where these quarries are, reaches the Desplaines at Lyons, as Dr. Henry M. Barrister reports in the Illinois Geological Survey. This gives a wide area for rain-fall, and would seem to afford a good supply for all the wells yet sunk or likely to be sunk. The conditions seem to be quite similar to those at Oshkosh, Wis., where artesian wells of three kinds are put down, and afford that city its supply of water. The first are sunk to the drift clay and beneath the surface red clay, the depth being about twenty feet; the second are put down through the blue clay to what Prof. Chamberlin calls the concrete, which consists of partially cemented sand and gravel, and lies immediately on the Niagara limestone. The third class is nearly like the shallow artesian wells of Chicago. Prof. Chamberlin says the flow originates in the rock, within from six to twenty feet of the surface. These wells do not overflow, but the water rises nearly to the surface of the ground, and perhaps a foot or two above the waters of lake Winnebago. Prof. Chamberlin thinks the source of supply is to the westward, and less than ten miles distant.

The question of the water supply in the shallow artesian wells is complicated by the fact that frequently sand pockets of large area, filled with gravel, sand and water, are met with imbedded in the boulder drift clay. A few years ago, when the city authorities were constructing a tunnel beneath the north branch, at Division street, for the water mains, at a depth of nineteen feet below city datum, and several feet below the bed of the river, a sand pocket, of dimensions so large as to make the word pocket a misnomer, was found. It was more like a broad stratum. The water rose in the shaft a foot or two above the level of the river, and this was the fact

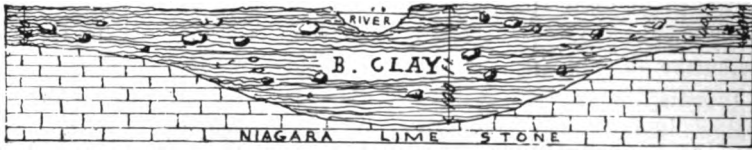
which enabled the city engineer to assume that it was not river water. Two powerful steam pumps, raising together 350 gallons per minute, were set to work, and were kept busy about two days before the water was exhausted, when, at length, it was all removed, and no further trouble experienced; but in the meantime, the docks for several feet on both banks of the river perceptibly settled, and old wells, which had always yielded water since their construction, were discovered to be dry, and persons living half a mile from the river, to the west, inquired what had been done to drain their wells. The shaft was sunk about seventy-five or eighty feet from the river. Similar trouble was met with when the excavation was made for the pumping engines at Ashland avenue and the south branch, which seems to indicate that the river has something to do with supplying the water.

It appears that the lower sand and limestone measures are formed of alternate solid and impervious layers, and broken and cracked strata. In deepening the well at Garfield Park, a few years ago, the contractor came across a layer of rock which seemed too brittle for the drill to pass through until a large cavity had been broken down and removed. The contractor of the new well recently finished for the West Park Commissioners, in the angle of the boulevard leading from Douglass Park to Garfield Park, says that at a depth of 1,148 feet the drill reached a seam about five feet across. The drill dropped that distance before touching solid rock again. In the meantime the water in the well, which had been overflowing, ceased entirely to reach the surface, and sunk to a level of about three feet from the top, and remained there until the seam was completely shut off by tubing. This well was sunk to a level of 2,317 feet. It contains $196\frac{1}{2}$ grains of solid matter in each gallon of water, more than half of which, or $134\frac{1}{2}$ grains, is common salt. This large seam, and the fact that it caused the overflow to cease for six weeks, or until the water at the seam could be shut off by tubing, is a curious fact.

The boring of so many wells in the city has made it comparatively easy to determine the topography of the surface, were the overlying mass of clay and drift entirely removed. It may be said in general that the Chicago river would flow nearly where it does now if the clay were entirely removed. In other words, the main river and two branches lie over depressions in the Niagara limestone corresponding to the river. The deepest clay is under and on both sides of the river, north and south, and along the branches. In the path of the main river, and for a distance of several squares, either side, it is 100 feet deep and over in some places. At Indiana street and the north branch it is 135 feet deep, and further up the river it ranges from 60 to 70 feet in depth. At Twenty-second street and Canalport avenue it is 100 feet deep; at Eighteenth street it is 70 feet deep. Between the south branch and the lake, at Libby, McNeil &

Libby's packing house, on State street and Sixteenth, the clay is 55 feet thick, and at the Consumer's Gas Company's well, at Twenty-fifth and Hanover streets, it is 37 feet thick. At 405 W. Madison street it is 90 feet thick. Were the drift wholly removed from the underlying limestone, and the water of lake Michigan kept from flowing in, the surface would be no longer a plane. A rocky knoll over 100 feet in height would appear at Milwaukee avenue and the old Toll Gate, having quite a wide area at top.

The following section across the main river will give a notion of the depth of clay.



Similar high elevations would appear at Eighteenth and Roby streets and at Twenty-fourth street and Archer avenue, while a ridge of rock would extend westward to the Desplaines and Lyons. At Van Buren street, on the South Side, there would be an ascent of sixty feet to a rocky upland at Sixteenth street, extending southward. These ridges are upheavals, as shown by the dip of the strata in general, coinciding with the slant of the surface, as at Archer avenue, Eighteenth street and Cicero quarries, and particularly the rocky ridge of Stony Island, near South Chicago. These elevations were in existence when the drift clay was laid down, as is shown by the planed-off surface of Stony Island, and the fact that the rock thus removed by glacial action is found in the tough clay which is deposited as a tail to this crag in a southwestern direction.

In conclusion, the facts seem to show that the water in the shallowest artesian wells has its source in the limestone outcroppings about and within the city, and partakes of the qualities of the rocks through which it passes in a pretty direct line from the outcropping to the lowest portions of the Niagara limestone. In some cases, as at 405 W. Madison street, the channel is a bed of sand and gravel, and the water is, therefore, very soft and pure. In others, as at the wells at Sixteenth and State streets, where there is iron and inflammable gas, the water doubtless passes through a rock rich in the products of organic remains. The overlying clay rests firmly and everywhere upon the rock and fills the superficial cavities for several feet.

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OF THE

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ON RHIZOCARPS

IN THE

ERIAN (DEVONIAN) PERIOD IN AMERICA.

Plate

BY SIR WILLIAM DAWSON, LL.D., F.R.S.

CHICAGO:

R. R. DONNELLEY & SONS, PRINTERS,

1886.



STUDY IN

CHINESE LITERATURE

BY

JOHN H. H. H. H.

OF THE UNIVERSITY OF MICHIGAN

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BY SIR WILLIAM DAWSON, LL.D., F.R.S.

(READ BEFORE THE ACADEMY, MAY 11, 1886.)

The motive of the present paper is to notice certain specimens of the organs of fructification of cryptogams obtained from the Erian shales of Canada and Ohio, and from shale boulders in the Chicago boulder clay, and from the clay itself, and which have been prepared for microscopic examination by Mr. B. W. Thomas, F. R. M. S. of Chicago. I have, however, thought it best to sum up the present state of our knowledge of the subject, in connection with the descriptions of the new specimens recently studied. The subject may thus be treated under the following heads:

1. Recapitulation of the progress of discovery in relation to *Sporangites* and their allies.
2. Description of specimens recently studied.
3. Mode of occurrence of the specimens in relation to their origin.
4. Classification and description of species.
5. General remarks.

I.—RECAPITULATION.

My attention was first directed to the organisms referred to in this paper by the late Sir W. E. Logan in 1869. He had obtained from the Upper Erian Shale of Kettle Point, Lake Huron, specimens filled with minute circular discs to which he referred, in his report of 1863, as "microscopic orbicular bodies." Recognizing them to be macrospores, or spore-cases, I introduced them into the report on the Erian Flora which I was then preparing, and which was published in 1871, under the name *Sporangites Huronensis*.

In 1871, having occasion to write a communication to the American Journal of Science on the question then raised as to the share of spores and spore-cases in the accumulation of coal, these curious little bodies were again reviewed and were described in substance as follows :

"The oldest bed of spore-cases known to me is that at Kettle Point, Lake Huron. It is a bed of brown bituminous shale, burning with much flame, and under a lens is seen to be studded with flattened disc-like bodies, scarcely more than a hundredth of an inch in diameter, which under the microscope are found to be spore-cases (or macrospores) slightly papillate externally, (or more properly marked with dark pores,) and sometimes showing a point of attachment on one side and a slit more or less elongated and gaping on the other. When slices of the rock are made, its substance is seen to be filled with these bodies, which, viewed as transparent objects, appear yellow like amber, and show little structure, except that the walls can be distinguished from the internal cavity, which may sometimes be seen to enclose patches of granular matter. In the shale containing them, are also vast numbers of rounded, translucent granules, which may be escaped spores (microspores)."

The bed containing these spores at Kettle Point was stated in the reports of the Geological Survey of Canada, to be 12 to 14 feet in thickness, and besides these specimens it contained fossil plants referable to the species *Calamites inornatus* and *Lepidodendron primævum*, and I not unnaturally supposed that the *Sporangites* might be the fruit of the latter plant. I also noticed their resemblance to the spore-cases of *L. corrugatum* of the lower Carboniferous, (a *Lepidodendron* allied to *L. primævum*), and to those from Brazil described by Carruthers under the name *Flemingites*, as well as to those described by Huxley from certain English coals, and to those of the Tasmanite or white coal of Australia. The bed at Kettle Point is shown to be marine by its holding *Spirophyton*, and shells of *Lingula*.

The subject did not again come under my notice till 1882, when Prof. Orton of Columbus, Ohio, sent me some specimens from the Erian shales of that state which on comparison seemed undistinguishable from *Sporangites Huronensis*. These shales have been described as to their Chemical and Geological relations, by Dr. T. Sterry Hunt, *Am. Journal of Science*, 1863, and by Dr. Newberry, in the Reports of the Geological Survey of Ohio, vol. I, 1863, and vol. III, 1878.

Prof. Orton read an interesting paper on these bodies, at the meeting of the American Association in Montreal, in which were some new and striking facts. One of these was the occurrence of such bodies throughout the black shales of Ohio, extending "from the Huron River on the shore of Lake Erie to the mouth of the Scioto in the Ohio valley, with an extent varying from ten to twenty miles in breadth," and estimated to be 350 feet in thickness.* Another was the absence of any traces of

*In a letter, received since the reading of this paper, Prof. Orton states that "borings in the Ohio black shale have penetrated it to a depth of 1800 feet without reaching the bottom." So that its whole thickness is probably much greater than stated in the text. Specimens of these borings kindly sent to me by Prof. Orton, are well filled with sporangites throughout the thickness of the shale as far as penetrated.
—B. W. T.

Lepidodendroid cones, and the occurrence of filamentous vegetable matter, to which the *Sporangites* seemed to be in some cases attached in groups. Prof. Orton also noticed the absence of the trigonal form, which belongs to the spores of many *Lepidodendra*, though this is not a constant character.* In the discussion on Prof. Orton's paper, I admitted that the facts detailed by him shook my previous belief of the lycopodiaceous character of these bodies, and induced me to suspect, with Prof. Orton, that they might have belonged to some group of aquatic plants lower than the *Lycopods*.

In the same discussion, Prof. Williams, of Cornell University, mentioned that he had found similar bodies in the Hamilton shales of New York, and that they were associated with the curious pinnately leaved plant *Ptilophyton vanuxemii*, an observation to which I subsequently referred in discussing the affinities of this fossil, in a report on the Erian plants of Canada, published in 1882.† Prof. Williams was kind enough to send me specimens, in which, however, the round spore-case-like bodies were much less distinct than in the specimens from Ohio and Lake Huron. In the report above referred to I have also noticed the occurrence of rounded spore-like bodies in association with the stems of *Trochophyllum* of Lesquereux from the lower carboniferous of Pennsylvania, and of which specimens were submitted to me by Mr. Lacoe, of Pittston, and Prof. Lesquereux. *Trochophyllum* I regard as closely allied to or perhaps congeneric with *Ptilophyton*, and in the report already referred to I have argued that these plants were probably aquatic.

Still more recently Prof. J. M. Clarke, of Northampton, Mass., was so kind as to send me two fragments of rock containing *Sporangites* similar to those above mentioned—one from the Genesee shale of Canandaigua, N. Y., and another from the Corniferous Limestone. In the latter these bodies retain their globular form, though some are partially crushed in such a way as to show their membranous character. In slices prepared by Prof. Clarke the wall is seen to be thin and carbonaceous, with indications of a dense cellular structure, and some of the specimens show a projecting aperture or point of attachment at one side, giving them a somewhat pear-shaped appearance. The size of all these macrospores from the Erian of New York is nearly the same with that of Lake Huron specimens. Those found with *Trochophyllum* in the Lower Carboniferous are much larger.‡

No certain clue seemed to be afforded by all these observations as to the precise affinities of these widely distributed bodies; but this was furnished shortly after from an unexpected quarter. In March, 1883, Mr.

*On the source of the Bituminous matter of the black shales of Ohio. Proc. Am. Asso. 1882.

†Report on Erian Plants of Canada, Part II.

‡Prof. Clarke has described his specimens in the American Journal of Science, April, 1885, and has noticed some interesting points to be referred to in the sequel.

Orville Derby, of the Geological Survey of Brazil, sent me specimens found along with fronds of *Spirophyton* in the Erian of that country, which seemed to throw a new light on the whole subject. These I described and pointed out their connection with *Sporangites* at the meeting of the American Association, at Minneapolis, in 1883, and subsequently published my notes respecting them in its Proceedings and in the Canadian Record of Science. Mr. Derby's specimens recalled to remembrance certain fossils which had been sent to me several years ago by the late Prof. Hartt, and which, like Mr. Derby's specimens, occurred in beds holding *Spirophyton*, though these were at that time regarded as carboniferous. In a note prepared for Prof. Hartt, but not, so far as I am aware, published, I had noticed these fossils as follows :

"*Sporangites*—Specimens from a shale at Rio Tapagos, above Itaituba.

"These are spore-cases, probably of a Lepidodendroid plant and resembling *S. Huronensis* of the Devonian of Canada. The specimens are labelled as Carboniferous, but the occurrence in them of abundant fronds of *Spirophyton* rather points to a Devonian date."

Mr. Derby's specimens contained *Spirophyton* and also minute rounded *Sporangites* like those obtained by Prof. Hartt. But they differed in showing the remarkable fact that these rounded bodies are enclosed in considerable numbers in spherical and oval sacs, the walls of which are composed of a tissue of hexagonal cells, and which resemble in every respect the involucre or spore-sacs of the little group of modern acrogens known as *Rhizocarps*, and living in shallow water. More especially, they resemble the sporocarps of the genus *Salvinia*. This fact opened up an entirely new field of investigation, and I at once proceeded to compare the specimens with the fructification of modern *Rhizocarps*.

Mr. Derby's specimens are labelled as from Rio Trombetos and Rio Curua. They occur in two kinds of matrix. One is a thinly laminated sandy shale, tinged red with peroxide of iron, and with occasional ferruginous laminae. In this the spore-sacs are flattened and black, and show the structure of the walls under the microscope. The contained macrospores, when visible, appear as minute tubercles, or sometimes as depressions on the wall of the envelope, or more frequently as round light colored spots, according to their state of preservation. The other kind of matrix is a gray, dense shale in which the spore-sacs appear less flattened and usually destitute of carbonaceous matter.

The very numerous spore-sacs or sporocarps contained in these shales were so variable in size and form that they may have belonged to several species of plants, though on the other hand the differences might be attributed to age and state of preservation. They resolved themselves, however, into two leading types, which I named and described as *Sporangites Braziliensis* and *S. bilobata*; suggesting for them at the same

time the generic name *Protosalvinia*, in case the affinities which I think indicated by their structure should be fully established in the future. In the meantime I may adhere to the name *Sporangites*, which, though not technically correct, when applied to the individual macrospores, is sufficiently accurate when taken in connection with their occurrence in groups surrounded by cellular Sporocarps. Its priority and its use (since 1865) also give it claims to consideration. It will therefore be understood that when I use this term I refer to macrospores like those of the Lake Huron shale, as well as to Sporocarps containing macrospores, as in the Brazilian specimens. The equivalent term *Protosalvinia* I shall use as a prospective name to be applied to the whole plant so soon as this shall be known.

Since the publication of my paper on Rhizocarps in the Palaeozoic Period above referred to, I have received two papers from Mr. Edward Wethered, F. G. S., in one of which he describes spores of plants found in the Lower Limestone shales of the Forest of Dean, and in the other discusses more generally the structure and origin of Carboniferous Coal beds.* In both papers he refers to the occurrence in these coals and shales of organisms essentially similar to the Erian spores.

In the Bulletin of the Chicago Academy of Science, January, 1884, Dr. Johnson and Mr. Thomas, in their paper on the Microscopic Organisms of the Boulder Clay of Chicago and vicinity, notice *Sporangites Huronensis* as among these organisms, and have discovered them also in large numbers in the precipitate from Chicago city water supply. They refer them to the decomposition of the Erian shales, of which boulders filled with these organisms are of frequent occurrence in the Chicago clays. The *Sporangites* and their accompaniments in the boulder clay are also noticed in a paper by Dr. G. M. Dawson, in the Bulletin of the Chicago Academy, June, 1885.

Prof. Clarke has also described, in the American Journal of Science for April, 1885, the forms already alluded to and which he finds to consist of Macrospores enclosed in Sporocarps. He compares these with my *Sporangites Huronensis* and *Protosalvinia bilobata*, but I think it is likely that one of them at least is a distinct species.

I may add that in the Geological Magazine for 1875, Mr. Newton, F. G. S., of the Geological Survey, of England, published a description of the Tasmanite and Australian white coal, in which he shows that the organisms in these deposits are similar to my *Sporangites Huronensis*, and to the Macrospores previously described by Prof. Huxley, from the Betterbed coal. Mr. Newton does not seem to have been aware of my previous description of *Sporangites*, and proposes the name, *Tasmanites punctatus*, for the Australian form.

* Cotteswold Naturalists' Field Club, 1884. Journal of Royal Microscopical Society, 1885.

Mr. R. Kidston, F. G. S., has recently been engaged in the examination of the spores and sporangia contained in Devonian and Carboniferous deposits in Scotland, and some of which, as he informs me, are similar to those referred to in this paper; but I have not yet seen his published results.

To the kindness of Mr. Thomas I am indebted for a large series of microscopic preparations of these fossils, and of others in the Bedford shale of Ohio, prepared from specimens sent to him by Prof. Orton, the results of the microscopic examination of which I propose to notice, and to inquire as to the inferences which are now warranted respecting the affinities of these organisms.

II.—DESCRIPTION OF THE SPECIMENS.

The typical macrospores from the Erian shales are perfectly circular in outline, and in the flattened state appear as discs with rounded edges, their ordinary diameter being from 1-75th to 1-100th of an inch, though they vary considerably in size. This, however, I do not regard as an essential character. The edges, as seen in profile, are smooth, but the flat surface often presents minute dark spots, which at first, I mistook for papillæ; but now agree with Mr. Thomas in recognizing them as minute pores traversing the wall of the disc, and similar to those which Mr. Newton has described in Tasmanite, and which Mr. Wethered has also recognized in the similar spores of the Forest of Dean shales. The walls also sometimes show faint indications of concentric lamination, as if they had been thickened by successive deposits.

As seen by transmitted light, and either in front or in profile, the discs are of a rich amber color, translucent and structureless, except the pores above referred to. The walls are somewhat thick, or from $\frac{1}{10}$ th to $\frac{1}{20}$ th the diameter of the disc in thickness. They never exhibit the triradiate marking seen in spores of Lycopods, nor any definite point of attachment, though they sometimes show a minute elongated spot which may be of this nature, and they are occasionally seen to have opened by slits on the edge or front, where there would seem to have been a natural line of dehiscence. The interior is usually quite vacant or structureless, but in some cases there are curved internal markings which may indicate a shrunken lining membrane, or the remains of a prothallus or embryo. Occasionally a fine granular substance appears in the interior, possibly remains of microspores.

The discs are usually detached and destitute of any envelope, but usually fragments of flocculent cellular matter are associated with them, and in one specimen from the carboniferous limestone of Ohio, in Mr. Thomas' collection, I have found a group of eight or more discs partly enclosed in a cellular sac-like membrane of similar character to that enclosing the Brazilian specimens already referred to.

The characters of all the specimens are essentially similar, and there is a remarkable absence of other organisms in the shale. In one instance only, I have observed a somewhat smaller round body with a dark centre or nucleus, and a wide translucent margin, marked by a slight granulation. Even this, however, may indicate nothing more than a different state of preservation.

It is proper to observe here that the wall or enclosing sac of these macrospores must have been of very dense consistency, and now appears as a highly bituminous substance; in this agreeing with that of the spores of Lycopods, and like them, having been when recent of a highly carbonaceous and hydrogenous quality, very combustible and readily admitting of change into bituminous matter. In the paper already referred to, on spore-cases in coals, I have noticed that the relative composition of lycopodium and cellulose is as follows:

Cellulose $C_{24} H_{20} O_{20}$

Lycopodium $C_{42} H_{19\frac{4}{12}} N O 5 \frac{6}{10}$.

Thus, such spores are admirably suited for the production of highly carbonaceous or bituminous coals, etc.

Nothing is more remarkable in connection with these bodies than their uniformity of structure and form over so great areas and throughout so great thickness of rock, and the absence of any other kind of spore-case. This is more especially noteworthy in contrast with the coarse coals and bituminous shales of the carboniferous, which usually contain a great variety of spores and sporangia, indicating the presence of many species of acrogenous plants, while the Erian shales on the contrary indicate the almost exclusive predominance of one form. This contrast is well seen in the Bedford shales overlying these beds, and I believe Lower Carboniferous.* Specimens of these have been kindly communicated to me by Prof. Orton, and have been prepared by Mr. Thomas. In these we see the familiar carboniferous spores with triradiate markings called *Triletes* by Reinsch, and which are similar to those of Lycopodiaceous plants. Still more abundant are those spinous and hooked spores or sporangia, to which the names *Sporocarpion*, *Zygosporites* and *Traquaria* have been given, and some of which Williamson has shown to be spores of Lycopodiaceous plants.†

The true "Sporangites" on the contrary are round and smooth, with thick bituminous walls, which are punctured with minute transverse pores. In these respects, as already stated, they closely resemble the bodies found in the Australian white coal and Tasmanite. The precise geological age of this material is not known with certainty, but it is believed to be Palaeozoic.

* According to Newberry, lower part of Waverly group.

† *Traquaria* is to be distinguished from the calcareous bodies found in the corniferous limestone of Kelly's Island, which I have described in the Canadian Naturalist as *Saccamina eriana*, and believe to be Foraminiferal tests. See Dr. Williamson's papers in transactions of Royal Society of London.

III.—MODE OF OCCURRENCE OF SPORANGITES, AND ITS BEARING ON THEIR ORIGIN.

Under this head we may note first the great abundance and wide distribution of these bodies. The horizontal range of the bed at Kettle Point is not certainly known, but it is merely a northern outlier of the great belt of Erian shales referred to by Prof. Orton, and which extends, with a breadth of ten to twenty miles, and of great thickness, across the State of Ohio, for nearly 200 miles. This Ohio black shale, which lies at the top of the Erian or the base of the Carboniferous, though probably mainly of Erian age, appears to abound throughout in these organisms and in some beds to be replete with them. In like manner, in Brazil, according to Mr. Derby, these organisms are distributed over a wide area and throughout a great thickness of shale holding *Spirophyton*, and apparently belonging to the Upper Erian. The recurrence of similar forms in the Tasmanite and white coal of Tasmania and Australia is another important fact of distribution. To this we may add the appearance of these macrospores in coals and shales of the Carboniferous period, though there in association with other forms.

It is also to be observed that the Erian shales, and the Forest of Dean beds described by Wethered, are marine, as shown by their contained fossils; and though I have no certain information as to the Tasmanite and Australian white coal, they would seem, from the description of Milligan, to occur in distinctly aqueous, possibly estuarine, deposits. Wethered has shown that the discs described by Huxley and Newton in the Better-bed coal occur in the earthy or fragmentary layers as distinguished from the pure coal. Those occurring in cannel coal are in the same case, so that the general mode of occurrence implies water-driftage, since in the case of bodies so large and dense, wind-driftage to great distances would be impossible.

These facts, taken in connection with the differences between these macrospores and those of any known land plant of the Palaeozoic, would lead to the inference that they belonged to aquatic plants, and these vastly abundant in the waters of the Erian and Carboniferous periods.

It is still further to be observed that they are not, in the Erian beds, accompanied with any remains of woody or scalariform tissues such as might be expected in connection with the debris of terrestrial acrogens, and that, on the other hand, we find them enclosed in cellular sporocarps, though in the majority of cases these have been removed by dehiscence or decay.

These considerations, I think, all point to the probability which I have suggested in my previous paper on this subject, that we have in these objects the organs of fructification of plants belonging to the order *Rhizocarpeæ*, or akin to it. The comparisons which I have instituted with the

sporocarps and macrospores of these plants confirm this suggestion. Of the modern species which I have had an opportunity to examine, *Salvinia natans* of Europe perhaps presents the closest resemblance. In this plant groups of round cellular sporocarps appear on the surface of the floating fronds. They are about a line in diameter when mature, and are of two kinds, one containing macrospores, the other microspores or antheridia. The first, when mature, hold a number of closely packed globular or oval sporangia of loose cellular tissue attached to a central placenta. Each of these sporangia contains a single macrospore, perfectly globular and smooth, with a dense outer membrane (exhibiting traces of lamination, and showing within an irregularly vacuolated or cellular structure, probably a prothallus). I can not detect in it the peculiar pores which appear in the fossil specimens. Each macrospore is about one-seventieth of an inch in diameter when mature. The sporocarps of the microspores contain a vastly greater number of minute sporangia, about one two-hundredths of an inch in diameter. These contain disc-like antheridia, or microspores of very minute size.

The discs from Kettle Point and from the Ohio black shale, and from the shale boulders of the Chicago clays, are similar to the macrospores of *Salvinia*, except that they have a thicker wall and are a little less in diameter, being about one-eightieth of an inch. The Brazilian sporocarps are considerably larger than those of the modern *Salvinia*, and the macrospores approach in size to those of the modern species, being one-seventy-fifth of an inch in diameter. They also seem, like the modern species, to have thinner walls than those from Canada, Ohio and Chicago. No distinct indication has been observed in the fossil species of the inner Sporangium of *Salvinia*. Possibly it was altogether absent, but more probably it is not preserved as a distinct structure.

With reference to the microspores of *Salvinia*, it is to be observed that the sporocarps, and the contained spores or antheridia, are very delicate and destitute of the dense outer wall of the macrospores. Hence such parts are little likely to have been preserved in a fossil state; and in the Erian shales, if present, they probably appear merely as flocculent carbonaceous matter not distinctly marked, or as minute granules not well defined, of which there are great quantities in some of the shales.

The vegetation appertaining to the Sporangites has not been distinctly recognized. I have, however, found in one of the Brazilian specimens two sporocarps attached to what seems a fragment of a cellular frond, and numerous specimens of the supposed Algæ, named *Spirophyton*, are found in the shales, but there is no evidence of any connection of this plant with the Protosalvinia.

Modern Rhizocarps present considerable differences as to their vegetative parts. Some, like *Pilularia*, have simple linear leaves; others, like

Marsilea, have leaves in verticils and cuneate in form; while others, like *Azolla* and *Salvinia*, have frondose leaves, more or less pinnate in their arrangement. The first type presents little that is characteristic, but there are in the Erian sandstones and shales great quantities of filamentous and linear objects which it has been impossible to refer to any genus, and which might have belonged to plants of the type of *Pilularia*. It is quite possible, also, that such plants as *Psilophyton glabrum* and *Cordailes angustifolia*, of which the fructification is quite unknown, may have been allied to Rhizocarps. With regard to the verticillate type, we are at once reminded of *Sphenophyllum*, which many palæo-botanists have referred to the *Marsiliaceæ*, though like other Palæozoic Acrogens, it presents complexities not seen in its modern representatives, *S. primevum* of Lesquereux is found in the Hudson River group, and my *S. antiquum* in the Middle Erian. Besides these, there are in the Silurian and Erian beds plants with verticillate leaves which have been placed with the Annulariæ, but which may have differed from them in fructification. *Annularia laxa*, of the Erian, and *Protannularia Harknessii*, of the Silurio-Cambrian, may be given as examples, and must have been aquatic plants, probably allied to Rhizocarps. It is deserving of notice, also, that the two best known species of *Psilophyton* (*P. princeps* and *P. robustius*), while allied to Lycopods by the structure of the stem and such rudimentary foliage as they possess, are also allied, by the form of their fructification, to the Rhizocarps, and not to ferns, as some palæo-botanists have incorrectly supposed.

The curious plants known as *Arthrostigma*, seem also to have been allied to *Psilophyton* in their fruit, though bearing it in spikes instead of as separate sporocarps.*

I would also here direct attention to those pinnate leaves from the Erian and Carboniferous, which I have named *Ptilophyton*, and to those from the Carboniferous, which Lesquereux has named *Trochophyllum*. I have fully discussed the structure of these in my Report of 1882 on the Erian Plants of Canada, and may here merely state that I have shown that they were aquatic plants, probably bearing sporocarps attached to their stems somewhat in the manner of *Azolla*.

The whole of this evidence, I think, goes to show that in the Erian period there were vast quantities of aquatic plants allied to the modern Rhizocarps, and that the so-called Sporangites referred to in this paper were probably the drifted sporocarps and macrospores of some of these plants or of plants allied to them in structure and habit, of which the vegetative organs have perished. I have shown that in the Erian period there were vast swampy flats covered with *Psilophyton*, and in similar submerged tracts near to the sea the *Protosalvinia* may have filled the waters and have given off the vast multitudes of Macrospores which drifted by currents have settled in the mud of the black shales.

* Report on Erian Plants of Canada, Part II, 1882.

III.—CLASSIFICATION OF SPORANGITES.

It is, of course, very unsatisfactory to give names to mere fragments of plants, yet it seems very desirable to have some means of arranging them. With respect to the organisms of the present paper, which were originally called by me *Sporangites*, under the supposition that they were Sporangia rather than Spores, this name has so far been vindicated by the discovery of the spore-cases belonging to them, so that I think it may still be retained as a provisional name; but I would designate the whole as *Protosalvinia*, meaning thereby plants with Rhizocarpean affinities, though possibly when better understood belonging to different genera. We may under these names speak of their detached discs as macrospores and of their cellular envelopes as sporocarps. The following may be recognized as distinct forms.

1.—*Protosalvinia Huronensis*, Dawson, Syn., *Sporangites Huronensis*, Report on Erian Flora of Canada, 1871.—Macrospores in the form of discs or globes, smooth and thick-walled, the walls penetrated by minute radiating pores. Diameter about $\frac{1}{10}$ th of an inch or a little more. When in situ several macrospores are contained in a thin cellular sporocarp, probably globular in form. From the Upper Erian, and perhaps Lower Carboniferous shales of Kettle Point, Lake Huron, of various places in the State of Ohio, and in the shale boulders of the boulder clay of Chicago and vicinity. First collected at Kettle Point by Sir W. E. Logan, and in Ohio by Prof. Edward Orton, and at Chicago by Dr. H. A. Johnson and Mr. B. W. Thomas, also in New York by Prof. J. M. Clarke.

The macrospores collected by Mr. Thomas from the Chicago clays and shales conform closely to those of Kettle Point, and probably belong to the same species. Some of them are thicker in the outer wall, and show the pores much more distinctly. These have been called by Mr. Thomas *S. Chicagoensis*, and may be regarded as a varietal form. Specimens isolated from the shale and mounted dry, show what seems to have been the hilum or scar of attachment better than those in balsam.

Sections of the Kettle Point shale show, in addition to the Macrospores, wider and thinner shreds of vegetable matter, which I am inclined to suppose to be remains of the Sporocarps.

2.—*Protosalvinia (Sporangites) Braziliensis*, Dawson, Can. Rec. of Sci., 1883.—Macrospores, round, smooth, a little longer than those of the last species, or about $\frac{1}{8}$ th of an inch in diameter, enclosed in round, oval or slightly reniform sporocarps, each containing from four to twenty-four macrospores. Longest diameter of sporocarps three to six millimeters. Structure of wall of sporocarps hexagonal cellular. Some sporocarps show no macrospores, and may possibly contain microspores. The specimens are from the Erian of Brazil. Discovered by Mr. Orville Derby. The formation, according to Mr. Derby, consists of black shales below, about

300 feet thick, and containing the furoid known as *Spirophyton*, and probably decomposed vegetable matter. Above this is chocolate and reddish shale in which the well preserved specimens of *Protosalvinia* occur. These beds are very widely distributed and abound in *Protosalvinia* and *Spirophyton*.

3.—*Protosalvinia* (*Sporangites*) *bilobata*, Dawson, Can. Rec. of Science, 1883.—Sporocarps, oval or reniform, three millimeters to six millimeters in diameter, each showing two rounded prominences at the ends, with a depression in the middle, and sometimes a raised neck or isthmus at one side connecting the prominences. Structure of sporocarp cellular. Some of the specimens indicate that each prominence or tubercle contained several macrospores. At first sight it would be easy to mistake these bodies for valves of *Beyrichia*.

Found in the same formations with the last species, though in so far as the specimens indicate, not precisely in the same beds. Collected by Mr. Derby.

4.—*Protosalvinia* *Clarkei*, Dawson, P. bilobata, Clarke, Am. Jl. of Science.—Macrospores $\frac{2}{3}$ to 1 millimeter in diameter. One, two or three contained in each sporocarp, which is cellular. The macrospores have very thick walls with radiating tortuous tubes. Unless this structure is a result of mineral crystallization, these macrospores must have had very thick walls and must have resembled in structure the thickened cells of stone fruits and of the core of the pear, or the tests of the Silurian and Erian seeds known as *Pachytheca*, though on a smaller scale.

It is to be observed that bodies similar to these occur in the Boghead earthy bitumen and have been described by Credner.

I have found similar bodies in the so-called "Stellar coal" of the coal district of Pictou, Nova Scotia, some layers of which are filled with them. They occur in groups or patches, which seem to be enclosed in a smooth and thin membrane or sporocarp. It is quite likely that these bodies are generically distinct from *Protosalvinia*.

5.—*Protosalvinia* *punctata*, Newton, Geol. Mag. N. S. Dec. 2, vol. II. Mr. Newton has named the discs found in the white coal and Tasmanite, *Tasmanites*, the species being *Tasmanites punctatus*, but as my name *Sporangites* had priority, I do not think it necessary to adopt this term, though there can be little doubt that these organisms are of similar character. The same remark may be made with reference to the bodies described by Huxley and Newton as occurring in the Better-bed coal.

V.—GENERAL REMARKS.

It may be well to mention here the various characters of pyroschists or bituminous shales of different ages, as they have come under my notice.

The Utica shale of Collingwood, Ontario, which has been used for the distillation of coal oil, shows under the microscope only flocculent matter and slender spicules, and its bitumen seems to have been derived from the disintegration of algæ and zoophytes.

A specimen of inflammable shale from the Trenton of Minnesota, prepared by Mr. Thomas, shows similar shreds of organic matter without any macrospores.

Bituminous shales associated with a small layer of coal in the middle Erian of Gaspe, show great quantities of shreds of epidermal tissue and fragments of the chitinous crusts of Eurypterids, but no distinct macrospores.

The richly bituminous shales of the Lower Carboniferous of Albert county, New Brunswick, which have furnished the material of the Albertite or hardened bitumen of that district, have not afforded any macrospores in the specimens I have been able to examine, but are filled with shreds apparently of vegetable matter in a much disintegrated state.

The Bedford shales of Ohio contain, in addition to fragments of epidermal and woody and vascular tissue, many forms of macrospores quite distinct from those of the underlying Erian shales. A similar remark may be made as to many varieties of coarse coal, cannel coal and bituminous shale of the coal measures, in which many forms of macrospores, and sporangia may be found mixed with shreds of the more durable tissues, and especially of the epidermal tissue of various kinds of plants. Dr. Newberry and Mr. Julian have described in the *Annals of the N. Z. Academy of Science*, 1883, a number of specimens of bituminous shales not containing Sporangites, and Dr. Newberry refers the bituminous matter to the decomposition of algæ, or in some cases to that of miscellaneous vegetable débris from the land, a conclusion which he has applied also to the cannel coals.

From these facts it would appear that the presence of Rhizocarpean macrospores is not a necessary condition of the formation of bituminous shales, earthy bitumens or coals. Yet it seems certain that the macrospores are the cause of the highly bituminous character of the shales which are charged with them. On the other hand, many highly bituminous shales, such as, for instance, some beds of the Utica shale and the Lower Carboniferous shales of Albert county, New Brunswick, depend for their inflammable matter on microscopic débris of an entirely different character.

In point of fact* any kind of epidermal or dense cortical tissue has chemical properties not very dissimilar from those of the tests of macrospores; and such tissues have, as I have elsewhere shown,† been mainly instrumental in the production of coal, in some layers of which, however, macrospores and sporangia occur in large quantity. In regard to strictly marine shales, while it is probable or suggested by Newberry, that algæ may have furnished the material of much of the bituminous matter, I confess I am inclined to attach some importance in this respect to the corneous substance of Graptolites and other Zoophytes, which is nearer in composition to corky and epidermal matter.

In a botanical point of view the facts stated in this paper show that in the Erian, and probably also in the Carboniferous age, the type of plants now represented by the Rhizocarps was very largely developed, and that the macrospores of these plants were produced in such abundance as to charge great thicknesses of shales over very large areas with these bodies, which, owing to the density and indestructible character of the outer test, have resisted decomposition and remain unmineralized in the mass, giving to it the same highly combustible character which would result from the mixture of a like amount of Lycopodium spores with similar sediment.

*See my paper on Spore-cases in Coal. American Journal of Science, 1871.

†Journal of Geol. Society of London, 1865, and American Journal of Science, 1871. Also Acadian Geology, 1878.

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A PAPER ON
Elephas Primigenius.

BY W. K. HIGLEY, PH.D.

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BULLETIN

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CHICAGO ACADEMY OF SCIENCE.

ELEPHAS PRIMIGENIUS.

By W. K. HIGLEY, PH. D.

(READ AT OCTOBER MEETING, 1886.)

During the past summer the Academy Museum has been enriched by a mounted specimen of that enormous animal of past ages, the mammoth, *Elephas primigenius*.

For this addition to our collection we are indebted to our President, Dr. Edmund Andrews, who with much labor kept the skeleton in view for many years, till the price was reduced to a reasonable sum, when he interested the following gentlemen in the matter, who, with himself, purchased the bones and presented them to the Academy: Hon. Wm. Bross, Philip D. Armour, John Crerar, Norman Williams, Joseph Frank, Wirt Dexter, Hamilton B. Bogue and the members of the Mastodon Club. Thus, by the kindness of these gentlemen the Academy comes into possession of the only bones, I believe, ever found in this country in a sufficient state of preservation or numbers to permit of mounting.

Inspection proved that these remains were not only worthy of our attention in the unmounted state, but also that they were in such a condition that they could, by restoring certain parts, be placed in their natural position. It was deemed wise to mount them, for in this condition they would be much more instructive. This was attempted and for the grand result of the effort, which stands in the museum, the second mounted mammoth in the world, the Academy is indebted to Dr. J. W. Velie, assisted by Messrs. J. L. Hancock, Kuh, C. S. Babcock and Dr. Wyllys Andrews. These gentlemen volunteered their services and worked arduously and skillfully for the greater part of two months.

The bones were found in the spring of 1878, in the southwest part of Spokane County, Wash., on the farm of a Mr. Copelin. The country is a rolling prairie, about 2,100 feet above the sea, extending from the Rocky Mountains to the Cascade Range. The water-courses are timbered, the rest treeless. The soil is a rich black loam with white clay subsoil. Hang-

man's Creek, about 350 feet wide, runs through this part of the county into the Spokane River, which is a tributary of the Columbia. The prairie is an excellent grain land, and in the wild state produces grass thirty inches high.

The remains of four mammoths were found on the upland in a marshy hollow, about fifty feet in diameter, formed by a spring oozing out of the black mud, whose waters flowed off in a narrow valley to Hangman's Creek, about three-fourths of a mile distant. The bones were exposed while ditching in order to drain the spot.

A very perfect skeleton of a smaller animal, supposed, by a gentleman who saw it, to be a horse, was exposed with the mammoth bones. It is worthy of note that in this spring-hole cattle and other animals were occasionally mired.

Neither of the four skeletons found was complete, and in mounting, it was not always possible to tell one individual from another. Besides the four adult skeletons, there was a fragment of a small pelvis, probably from a fetus of one of the female mammoths dying pregnant.

The following is a list of bones found:

- 3 lower jaws, with teeth perfect.
- 13 cervical vertebræ.
- 20 dorsal vertebræ.
- 4 lumbar vertebræ.
- 9 caudal vertebræ.
- 1 sacrum.
- 2 pelves, one entire, and one supposed foetal fragment.
- 3 scapulas.
- 2 femurs, one a fragment.
- 1 patella.
- 1 ulna, a fragment.
- 2 humeri, one a fragment, and the other from another locality.
- 6 tusks.
- 7 upper molars and fragments.
- 32 ribs.
- 1 skull, merely some small fragments.
- 14 bones of the feet.

Thus the total number of bones, or their fragments, found was 121.

The total weight of the bones was about 700 pounds.

It will be noticed that the most important bones needed in making the measurements necessary for supplying the lost parts, in the process of restoration, were present. The work of restoration was done with conscientious care, using, when necessary, the bones of one of the smaller animals as patterns in modeling for the larger. In a few cases the bones of the *Elephas Indicus*, which are almost identical in form, served as patterns.

The height as it stands is 13 feet, while that of the St. Petersburg mammoth is only 9 feet 3 inches.

It will be of interest to compare the height of a few elephantine forms.

Jumbo's skeleton, *Elephas Africanus*, is 10 feet 3 inches; Warren's *Mastodon giganteus*, at Boston, is 11 feet, and the Hauser *Elephas Indicus* at Northwestern University, Evanston, Ill., is 10 feet 8 inches.

If we allow two inches for the gristly cushion under the feet, and three inches for the thickness of the flesh on its back, and some few inches for the wool and bristly mane, which is said to have crested the spine in the St. Petersburg specimen, it would seem that this animal, when living, must have been about 14 feet in height.

Some elephantine bones of great size have been reported from our western territories and attributed to *Elephas imperator*. If there is any adequate proof of such a species, our enormous specimen doubtless belongs to it, but the great size is not sufficient to prove a separate species when three smaller individuals were found in the same small area. Besides, the tusks have the peculiar and strong curve characteristic of the *Elephas primigenius*, and not known in any other elephant. The tusks were 9 feet 10 inches long measured on the outer curvature.

The teeth also correspond with those of the mammoth.

The following are some measurements of true bones in the mounted skeleton:

Length of tusk, 9 feet 10 inches.

Circumference of tusk at the base, 21 inches.

Number of laminæ of lower teeth, 19.

Breadth of lower teeth, $3\frac{1}{2}$ inches.

Length of lower teeth, 10 inches.

Breadth of lower jaw at the condyles, 23 inches.

Length of lower jaw, 22 inches.

Breadth of atlas, 18 inches.

Height of atlas, $9\frac{1}{2}$ inches.

Height of pelvis, 34 inches.

Breadth of pelvis, 62 inches.

Height of scapula, 39 inches.

Breadth of scapula, 25 inches.

Length of humerus, 45 inches.

Circumference of humerus at middle of shaft, 19 inches.

Dana says: "This ancient elephant was over twice the weight of the largest modern species, and nearly a third larger. The body was covered with a reddish wool and long black hair. One of the tusks measured $12\frac{1}{2}$ feet in length; it was curved nearly into a circle, though a little obliquely.

* * * At the mouth of the Lena one of these animals was found, at the beginning of this century, frozen and encased in ice. It measured 16 feet

4 inches in length to the extremity of the tail, exclusive of the tusks, and 9 feet 4 inches in height. It retained the wool on its hide, and was so perfectly preserved that the flesh was eaten by the dogs." [Manual of Geology, p. 565.]

So far as I am able to find, the species in Europe does not, on the average, exceed the stature of the living elephants, but this may be an error, or it may be that the climate and soil of our Western mountains and plains favored a larger stature in the species than in Siberia and Europe.

Perhaps at this point it would not be out of place to mention the "Lenape Stone," which has been made the subject of an exhaustive study by Mr. H. C. Mercer. This stone was found in Bucks County, Penn., in 1872. It has given rise to considerable discussion concerning its authenticity. A drawing on the stone represents the Indians in battle with the "hairy mammoth." Mr. Mercer holds that this is evidence indicating that the mammoth was contemporaneous with the American Indians. He believes in its authenticity, and has collected considerable evidence supporting his opinions, giving them to the public in a monograph published by G. P. Putman's Sons.

The spring-hole, in which the mammoth remains were found, was about 6 or 8 miles from a range of the Rocky Mountain system which separates the prairie country from Lake Coeur d'Alene. These mountains are heavily timbered everywhere. The habits of all the wild animals there is to keep to the mountains in the summer, but to retire to the prairie at the approach of winter, and the following spring to follow the receding snow up the mountain side again. Probably the mammoth did likewise. Prof. Baird says mammalian animals in general are taller and larger in proportion as their habitat is well north or in mountainous regions. This, with good food, may have resulted in an enormous growth. It may be that the grass on the fertile prairie, growing very luxuriantly, may have served as a food.

The mammoth, and in fact all elephantine remains, are usually found in groups composed of two or more individuals. At least four animals were entombed in one spot at the locality where the Academy specimen was found. Our former Director, Robert Kennicott, reported that in Alaska the bones of this species sometimes lie in clusters of several individuals. The Indians informed him of a valley where immense numbers of elephantine bones lay due, as they supposed, to a great battle among supernatural beings.

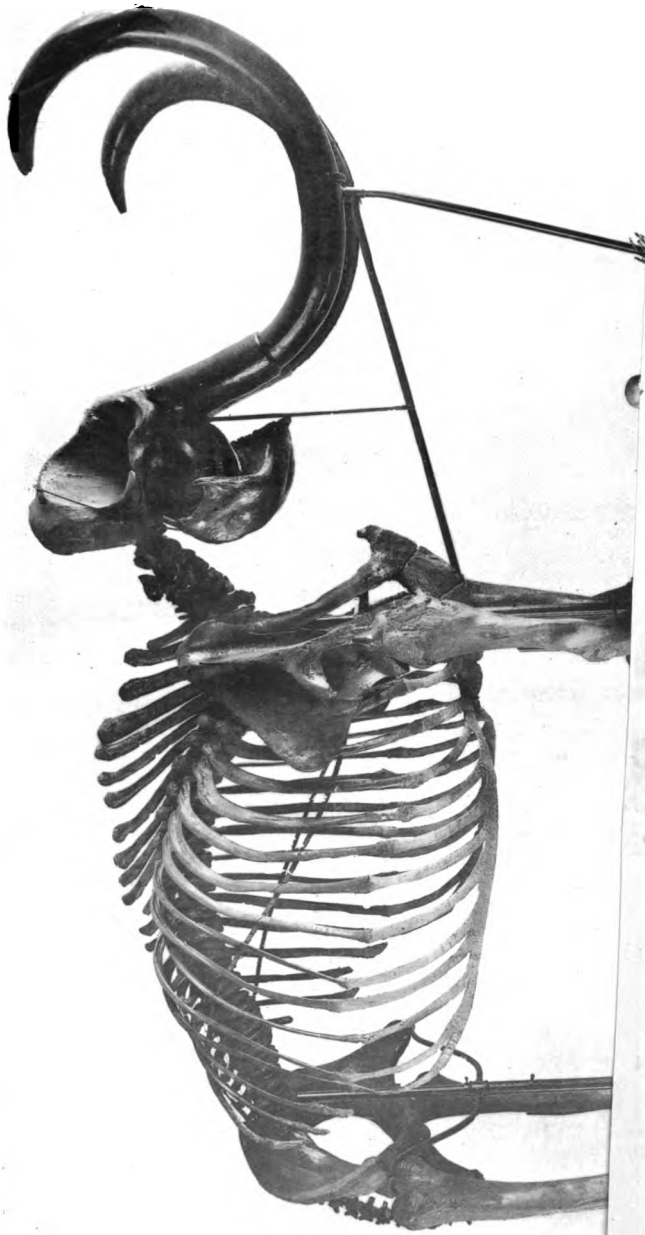
Dr. Stimpson exhumed, at Fort Wayne, Ind., three mastodons from one spot. In the island of Malta the extinct elephants are said to be huddled together in the upper valleys. It is thought by some that they were driven up by a submergence, and perished in groups in consequence.

The natives around the elephant lands of Hindostan think that the animals are in the habit of resorting to certain spots, deep in the forest, when they feel the approach of death, and thus leave their bones in groups.

If vast numbers exist in elevated valleys we might naturally admit the theory of their being driven together by the submergence which enclosed the Siberian specimen in frozen mud; but when only three or four are found together, we believe that the following theory is more plausible.

Animals, like men, when taken with fatal diseases, often suffer with thirst long after they have lost all desire for food and in fact have become too weak to travel after it. They might, therefore, be expected to loiter in and around their drinking places and to die there, one at a time, but ultimately accumulating in numbers.

Prof. Marsh, of Yale, informed Dr. Andrews that he had an unmounted Siberian mammoth in the museum store-room. So far as we know, that one and ours are the only nearly complete skeletons in this country, and ours the only mounted one.



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